Risk and the Response to Sea Level Rise in South Florida

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RISK AND THE RESPONSE TO SEA LEVEL RISE IN SOUTH FLORIDA

By

Galen Treuer

A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

August 2017
UNIVERSITY OF MIAMI

A dissertation submitted in partial fulfillment of
the requirements for the degree of
Doctor of Philosophy

RISK AND THE RESPONSE TO SEA LEVEL RISE IN SOUTH FLORIDA

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No. of pages in text. (195)

South Florida’s low elevation, intensive urban development, and delicate ecosystems make it vulnerable to sea level rise. Like many vulnerable communities, there is a gap between the current policies local governments in South Florida are pursuing and adaptive interventions that could significantly reduce their exposure to climate change risks, including sea level rise. One reason for this gap is that climate adaptation requires a transition away from the status quo, and barriers, including the psychological distance of climate change and conflict between governments about how best to respond, impede change. This dissertation presents background on the problem of sea level rise in South Florida (Chapter 1) and then three related studies that aim to help communities in the region embrace their climate change risks and experiment with actions that can reduce those risks. Chapter 2 reports the findings of an immersive simulation experiment that accelerated 348 South Florida homeowners through thirty-five years of sea level rise. Though most homeowners are not worried now, over 70%, across all demographic groups are willing to support public investments in adaptation, but as sea levels rise they become increasingly worried and willing to move out of the region. This suggests there is a window for local governments to respond to sea level rise. Chapter 3 is a case study of local government response, in the City of Miami Beach. Analyzed through the lens of
urgency, barriers, and risk, it follows the planning and implementation of a $500 million climate adaptive stormwater infrastructure investment during a period of accelerated policy change beginning in late 2013. Chapter 4 identifies a new role, that of the neo-oliemannahete, that has emerged in the Netherlands over the past two decades to support climate adaptive water management projects. The neo-oliemannahete is a third-party facilitators whose role is to build consensus and articulate co-benefits to manage technical and political challenges and overcome barriers to policy change. If applied in South Florida, this role has the potential to play a role in accelerating the regional response to sea level rise. Chapter 5 draws conclusions from the three studies, providing detailed recommendations on how local governments can act now to take advantage of the window of opportunity, clearly identify and communicate climate risks, invest in professional facilitation, and collaborate with academics to pursue climate adaptation experiments.
ACKNOWLEDGEMENTS

The research in this dissertation could not have been completed without the support of many individuals. It was a collaborative effort from the start, and I am eternally grateful for my collaborators, my advocates, and the amazing community that embraced me in Miami. I would like to thank my parents, Mary and Paul, my sisters, Ramona and Eva, my grandparents, Bob, Nancy, John, and Jean, and my oldest friend Brian who would be the most proud. Thank you to my advisor Kenny Broad for taking a risk on me, providing the support, and holding the space that made all of this possible. Thank you to Gina Maranto and Andee Holzman for your guidance, friendship, and ability to solve all problems. Thank you to my cohort, Andrew, Deborah, Stacy, and John, and the rest of the Abess students. A special thank you to the staff of the Miami-Dade Water and Sewer Department, Miami-Dade County, Broward County, City of Miami, South Florida Water Management District, and especially the City of Miami Beach for your constant generosity and openness.

Generous support for research in this dissertation was provided by the National Science Foundation's (NSF) Water, Sustainability, and Climate (WSC) Program (EAR-1204762) with joint support from the United States Department of Agriculture's National Institute of Food and Agriculture (NIFA Award Number 2012-67003-19862); the NSF Graduate Research Fellowship (Grant No. DG1E-0951782); the NSF Graduate Research Fellowship Worldwide program; the Netherlands Organization for Scientific Research (NOW) and Wageningen University; and the Leonard and Jayne Abess Center for Ecosystem Science and Policy at the University of Miami.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF FIGURES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>v</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vi</td>
</tr>
</tbody>
</table>

## Chapter

1. **INTRODUCTION: THE PROBLEM OF SEA LEVEL RISE IN SOUTH FLORIDA** ................................................................. 1

2. **HOMEOWNER RISK PERCEPTION: USING SIMULATIONS TO FORECAST HOMEOWNER RESPONSE TO SEA LEVEL RISE** .......... 36

3. **URGENCY, BARRIERS, AND RISK IN ACCELERATED CLIMATE ADAPTATION: THE CASE OF MIAMI BEACH** .............................. 69

4. **THE NEO-OLIEMANNETJE: PROFESSIONAL POLICY ENTREPRENEURS IN ADAPTIVE DUTCH WATER MANAGEMENT** ................................. 109

5. **CONCLUSIONS: RECOMMENDATIONS FOR LOCAL GOVERNMENTS AND COLLABORATIVE FUTURE RESEARCH** .............................. 149

## References

................................................................................................................. 170

## Appendices

................................................................................................................. 190

**APPENDIX A** ................................................................................................. 190
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>11</td>
</tr>
<tr>
<td>1.2</td>
<td>22</td>
</tr>
<tr>
<td>1.3</td>
<td>25</td>
</tr>
<tr>
<td>2.1</td>
<td>41</td>
</tr>
<tr>
<td>2.2</td>
<td>49</td>
</tr>
<tr>
<td>2.3</td>
<td>50</td>
</tr>
<tr>
<td>2.4</td>
<td>53</td>
</tr>
<tr>
<td>2.5</td>
<td>54</td>
</tr>
<tr>
<td>2.6</td>
<td>55</td>
</tr>
<tr>
<td>2.7</td>
<td>56</td>
</tr>
<tr>
<td>2.8</td>
<td>57</td>
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<tr>
<td>2.9</td>
<td>59</td>
</tr>
<tr>
<td>2.10</td>
<td>60</td>
</tr>
<tr>
<td>2.11</td>
<td>61</td>
</tr>
<tr>
<td>2.12</td>
<td>63</td>
</tr>
<tr>
<td>2.13</td>
<td>64</td>
</tr>
<tr>
<td>3.1</td>
<td>76</td>
</tr>
<tr>
<td>3.2</td>
<td>81</td>
</tr>
<tr>
<td>3.3</td>
<td>83</td>
</tr>
<tr>
<td>3.4</td>
<td>106</td>
</tr>
<tr>
<td>3.5</td>
<td>107</td>
</tr>
<tr>
<td>3.6</td>
<td>107</td>
</tr>
<tr>
<td>3.7</td>
<td>108</td>
</tr>
<tr>
<td>4.1</td>
<td>120</td>
</tr>
<tr>
<td>4.2</td>
<td>133</td>
</tr>
<tr>
<td>4.3</td>
<td>136</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table                                                                 Page
1.1 Categories of common climate adaptation barriers ........................................ 20
3.1 Risks identified and adaptation actions pursued by the Blue Ribbon Panel....  87
3.2 Barriers to initial adaptation actions pursued by Miami Beach...............  88
4.1 Actions performed by neo-oliemnetje to catalyze policy change ................ 140
4.2 Three skills commonly used by neo-oliemnetjes ..................................... 141
4.3 Four steps organizations can take to support a neo-oliemnetje............... 143
Chapter 1

Introduction

The Problem of Sea Level Rise in South Florida
1.1 Motivation

South Florida is threatened by sea level rise. How its local governments respond to the impacts of a changing climate will determine whether it will be able to support its population, economy, and environment in the future. Scientists are clear and confident that increased concentrations of greenhouse gases in the atmosphere are causing a number of problematic changes to the climate. These include higher temperatures, shifting precipitation, less stable seasonal weather patterns, stronger storms, and sea level rise (IPCC, 2015).\(^1\) If greenhouse gas emissions are not reduced significantly within the next decade sea levels in the United States are projected to rise over 0.5 meters (1.5 feet) by 2050 and 2.0 meters (6 feet) by 2100 (Sweet et al., 2017). The need to adapt to the changing climate is unquestionable if communities in the United States are going to maintain their current standard of living in the future, including water supply and protection against damaging floods (Bierbaum et al., 2013a; IPCC, 2014).

Florida’s vulnerability to sea level rise is well established, and South Florida is more exposed than the rest of the state due to its low elevation, intensive urban development, and delicate ecosystems (Noss, 2011). Its drinking water supply is threatened by salt water intrusion (Hughes and White, 2014). It has hundreds of billions of dollars in high-value property built at low elevation exposed to flooding from tides,

\(^1\) Concentration of carbon dioxide has passed 400 ppm, a level of concentration that has not been experienced on earth in 3 million years. There is nothing specifically dangerous about 400 ppm, but it is a milestone and a reflection of the irreversible nature of the problem, at least in the timeframe of human culture. Emissions continue to increase, driven particularly by rapidly developing economies. Even if emissions are reduced on an annual level, e.g., back to 1990 levels, the increase in concentration slows but does not reverse until carbon can be taken back up by natural systems. It is unclear how long that will take, but it is clear that negative impacts are already being felt by human society and ecosystems.

For additional information, see NOAA’s greenhouse gas concentration reports: https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases or https://climate.nasa.gov/vital-signs/carbon-dioxide/
rain, and storm surge (Hanson et al., 2011). Ecosystems, including the Everglades, would be permanently transformed by multiple feet of sea level rise (Nungesser et al., 2015). Infrastructure like dykes and canals, effective in the Netherlands and New Orleans, is unfeasible because of South Florida’s porous limestone bedrock (Obeysekera et al., 2011).

Communities, institutions, and individuals constantly adjust their behavior in response to changes in the climate, and a growing number are working to prepare for projected climate impacts through adaptation (Adger et al., 2005).^2 Though climate change is a global problem, most impacts will be experienced locally and efforts to adapt are most often implemented by local governments (Ford et al., 2011; Nordgren et al., 2016; Romero-Lankao et al., 2014). Proactive investments in adaptation can be cost-effective (Bierbaum et al., 2013a; Gordon, 2014; Hallegatte et al., 2013a) and South Florida has begun to respond (Vella et al., 2016). However, it will take a transformational change in tactics and policy by cities and counties (Kates et al., 2012) to dynamically respond to new vulnerabilities as they emerge intertwined with the unintended consequences of adaptation experiments (Dilling et al., 2015).

Transitioning is difficult. For individuals, climate change feels psychologically distant – impacts occur in the future, are geographically far away, or scientifically uncertain – which decreases worry and willingness to respond (Spence et al., 2012).

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^2 Adger et al.(2005) define climate adaptation as "an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities." They recognize adaptation as a process of adaptive capacity building and decision implementation through a “continuous stream of activities, actions, decisions and attitudes that [inform] decisions about all aspects of life, and that [reflect] existing social norms and processes,” and successful adaptation is measured by its effectiveness, efficiency, equity and legitimacy.
Institutionally, climate problems are wicked: addressing one problem, e.g., installing pumps to lessen chance of flooding from sea level rise, often reveals or produces more problems, e.g., increased pollution and public realization that pumps are a short-term fix to a long-term problem (Termeer et al., 2016). Adaptation requires cross-jurisdictional coordination and involves contentious tradeoffs between current and future threats. Overall, a shortage of political will and the tendency to procrastinate on challenging decisions means most communities will stick with the status quo until they are shocked into action, at which point it is often too late for a cost-effective, efficient, and equitable response (Biesbroek et al., 2013). It remains to be seen whether South Florida will be able to respond to this risk before the costs of adaptation rise exponentially. This central question of this dissertation is:

*How can communities in South Florida, faced with the threat of climate change induced sea level rise, overcome scientific uncertainty, behavioral biases, and governance challenges as they transition from inaction to adaption?*

Three related research projects identify practical actions communities in South Florida can take to accelerate their response to sea level rise along with theoretical findings on risk perception, climate adaptive risk management, adaptation barriers, and policy transitions. The first study (Chapter 2) uses a new immersive online simulation tool to help 348 South Florida homeowners experience thirty-five years of sea level rise. It gauges their support for public investments in climate adaptation, their willingness to move out of the region, and how the information they collect influences those decisions. The second (Chapter 3) is a case study of local government response to sea level rise in the City of Miami Beach. Analyzed through the lens of urgency, barriers, and risk, it follows the planning and implementation of a $500 million climate adaptive stormwater
infrastructure project during a period of accelerated policy change beginning in late 2013. The third study (Chapter 4) identifies a new role, the *neo-oliemannetje* (nee-o o-lee-man-it-che), that has emerged in the Netherlands over the past two decades to support climate adaptive water management projects. These third-party facilitators manage technical and political challenges to overcome barriers, including stakeholder and jurisdictional conflict. Guiding principles for the role of *neo-oliemannetje* are identified with the goal of application in South Florida.

Cumulatively, this research demonstrates that South Floridians are willing to support investments in climate adaptation. Through well-facilitated adaptation, vulnerable cities like Miami Beach are able to prepare for climate change and encourage residents and investors to remain despite sea levels rise. Collaboration with the Dutch and academics can provide governments in South Florida with new tools to manage their exposure to climate change by pursuing proactive adaptation.

The remainder of this first chapter provides an overview of the sea level rise challenges facing South Florida, including its physical, economic, and legal exposure – illustrated with a story of the unexpected consequences of Miami Beach raising its streets. It then briefly introduces relevant literature on climate adaptation, barriers to adaptation, governance transitions, and risk, with a focus on water management, that motivate and support the three broadly interdisciplinary studies that follow.

### 1.2 Exposure to Sea Level Rise in South Florida

The region of South Florida covers roughly a geographical third of the state of Florida and is home to 8 million people. It has two national parks, a large agricultural region, and the metropolitan area arguably most economically exposed to sea level rise of
any city in the world – the urban area around the Miami Metropolitan Statistical Area. Gilbert White, the godfather of flood management, warned that, "floods are an act of God, but flood losses are largely an act of man" (1945). Miami’s flood risk is the result of canals built to lower the natural water table combined with policies that encourage high value development in low lying areas. Vulnerability is defined as exposure to harm and the ability to respond to that harm (Hommels et al., 2014). It is the primary way in which urban exposure to climate change is discussed within the scientific community (Adger, 2006). However, instead of framing risks, including climate impacts, in terms of “vulnerability”, local governments often frame decisions about future threats as “risk management” and conduct cost-benefit analyses when deciding on specific responses to reduce exposure to future threats (Boholm, 2015), rather than focusing on adaptive capacity (Dilling et al., 2015). The next section discusses South Florida’s exposure to sea level rise, including physical, economic, and legal factors that limit or bolster its ability to manage risk.

1.2.1 Physical Exposure

South Florida is the lowest-lying region in a low coastal state. 10% of Florida is less than 1 meter (3 feet) above sea level. If sea levels rise 2 meters (6 feet) by 2100, millions of Floridians will be displaced (Hauer et al., 2016) and over $400 billion in homes will be submerged (Rao, 2016). Today, seasonal tidal flooding is a regular occurrence in many parts of South Florida. Water management in the region is complicated by its geology – shallow soils on top of porous limestone bedrock. This allows ocean water to pass under sea walls and infiltrate groundwater – the primary source of fresh water (Park et al., 2011). Additionally, Everglades National Park is a
fragile ecosystem only 1 meter above sea level, protected by complex regulations. The Water Resources Act of 2000 limited damaging agricultural runoff from the Everglades Agricultural Area (EAA) into the naturally low nutrient ecosystem. Since then, regional water managers who must balance the needs of ecosystems, agriculture, urban water supply, and flood protection face difficult choices when there is excess water in the EAA (Bolson and Treuer, 2014).

Water management is governed regionally by the South Florida Water Management District (SFWMD), the largest of five water management districts in Florida. It operates one of the most complex canal and pump systems in the world in coordination with the United States Army Corps of Engineers (ACOE) as well as county and municipal governments, who are responsible for local flood control infrastructure. SFWMD permits agricultural, industrial, municipal, and environmental water use in the region. Its main decision-making body is a board appointed by the state governor, and its activities are funded through a regional property tax. SFWMD was a pioneer in the use of climate information to guide management decisions (Bolson and Broad, 2013). It has the scientific knowledge, financing, and authority to take action, but that does not mean it has the political will to make difficult tradeoff decisions that will benefit some parties over others (Bolson and Treuer, 2014). All of these decisions are complicated by climate change and sea level rise.³

Sea levels are rising globally at a rate of 3.1 mm per year since 1993, twice the historic rate of 1.1 mm in the century before 1990 (Dangendorf et al., 2017). This

³ Rick Scott, the current governor of Florida, will not discuss the implications of climate change and has been hostile to his staff using the words. This combined with an ideological opposition to increased taxes appears to have made his appointees to the SFWMD governing board less than enthusiastic about making tough decisions on infrastructure investments that will be impacted by climate change (field notes).
increase is linked to higher global air temperatures due to climate change. On the east coast of North America, the rate of relative rise (a combination of the ocean rising and land subsiding) has been even faster, though scientists have not been able to identify whether this is the result of a slowing of the Gulf Stream current or natural variability, including the dynamic redistribution of ocean mass due to short and long-term changes in atmospheric conditions and reduced mass in Greenland and Antarctica as ice sheets melt (Sweet et al., 2017). Higher sea levels have led to a sharp increase in nuisance tidal flooding in coastal cities, damaging infrastructure and property (Sweet and Park, 2014). Higher seas also increase the frequency of flood damage from storms, increasing storm surges and negatively impacting the ability of existing stormwater systems. This necessitates more expensive infrastructure to provide the same level of flood protection (Buchanan et al., 2016; Hinkel et al., 2014).

Future sea level rise depends upon greenhouse gas emissions and the rate of melt in the Antarctic and Greenland ice sheets. Uncertainty about recent trends and future sea levels will be reduced within the next decade as more observations are made and uncertainty about future greenhouse gas emissions is resolved (Haigh et al., 2014; Mengel et al., 2016). There are no easy solutions in South Florida once sea levels rise past 1 meter. Tradeoffs will have to be made between flood protection in some areas and fresh water supply for the region (Obeysekera et al., 2011). The United State Geological Survey and local water utilities have developed new models that combine surface and groundwater interactions to estimate the impact of sea level rise. If salinity barriers and canals operated by SFWMD are maintained, an unsettled political question, then water
supplies should be secure across a range of sea level rise scenarios but flooding will be more frequent (Hughes and White, 2014).

### 1.2.2 Economic Exposure

The future economic risk to the Miami region is massive. One study comparing flood risk in coastal cities around the world found that 0.4 meters of sea level rise in 2050 would result in anticipated annual flood losses in the Miami metropolitan area of $25 billion, compared with less than $1 billion in anticipated losses today (Hallegatte et al., 2013a). If current flood protections can be maintained with 0.4 meters of sea level rise, these losses could be reduced to $2.5 billion (Hallegatte et al., 2013a). However, a rise that rapid would be likely to continue to accelerate beyond 2050 (Sweet et al., 2017), making future solutions more expensive as more assets are exposed to flooding and potential losses increase further.

Exposure to economic losses in South Florida is not evenly distributed. Many exposed assets are owned by wealthy investors, but poor residents are less able to prepare for climate impacts and respond to disasters like flooding when they inevitably arrive, increasing their relative vulnerability (Chakraborty et al., 2014). Some of the most vulnerable communities are on the western, inland side of Miami-Dade county and receive less attention than coastal cities like Miami Beach. Despite being far from the ocean, these communities are relatively low and flood prone (Collins et al., 2017). Low income residents’ vulnerability is compounded by the fact that most South Florida residents are unaware of their risk of flooding or the elevation of their home (Bolter, 2014).
One bright spot in South Florida is the Southeast Florida Climate Change Compact (the Compact), an association of Broward, Miami-Dade, Monroe, and Palm Beach counties that works to coordinate climate mitigation and adaptation efforts across county lines. It was founded in 2009 with the goal of influencing legislation and funding decisions at the state and federal level (Southeast Florida Climate Change Compact, 2012). Through the support of the Kresge Foundation and others it has expanded its reach and become a hub for knowledge sharing and regional planning. It supports professional development, promotes climate actions, and provides a means for staff to work with academics from regional universities and scientists at agencies like SFWMD. Its voluntary collaborative governance model has attracted attention from communities around the United States and the world (Vella et al., 2016).

The Compact has convened leading scientists and representatives from federal and local agencies to create a unified sea level rise projection. Updated most recently in 2015, these projections provide a standard for communities to coordinate their response, functionally reducing sea level rise uncertainty for decision makers (Sea Level Rise Working Group, 2015). Neighboring cities and counties can coordinate infrastructure investments, and perhaps equally important municipalities can legally justify their adaptation policies, e.g., raising streets and installing pumps in Miami Beach, with the backing of vetted sea level rise scenarios.

1.2.3 Legal Exposure

On October 3, 2016 a surprise downpour hit Miami Beach’s Sunset Harbour neighborhood. The streets, recently elevated to 1.1 meters (3.7 feet) above sea level as part of a $500 million sea level rise adaptation program, filled with water. Unfortunately,
pumps meant to clear stormwater and protect neighboring property (see Figure 1.1) were not fully functional. Water flooded into Tony Gallo’s restaurant causing $15,000 in damage. This flooding was frustrating for the restaurant owner who said, “We’re going to have to pay the price for [the city’s] experiment.” Gallo’s insurance company Allstate denied his damage claim because the National Flood Insurance Program (NFIP) decided that because the restaurant now sits below street level, it is considered to be located in a basement. The city of Miami Beach disagreed, arguing that raising the street did nothing to the elevation or status of Gallo’s restaurant and that they had certified this with the Federal Emergency Management Administration (FEMA) which administers NFIP (Flechas, 2016). In February 2015, city staff promised residents and business owners in Sunset Harbour that this exact type of flooding would not happen, and now some residents in other neighborhoods are not sure they want the streets raised (Field notes February 18, 2015).
This story is indicative of the dilemma coastal communities like Miami Beach face as sea levels rise. If they do not prepare, property and residents will be harmed. When they take action, new legal problems arise. They must negotiate their responsibility or duty to protect the safety and welfare of citizens while respecting the rights of property owners. Florida, like many states, has an evolving legal landscape for local government adaptation (Markell, 2016). Because the American legal system is to a great degree based on precedent, it is inherently and by design a slowly adapting bramble bush, to use a famous analogy (Llewellyn, 1930). This is good because it provides “a basis from which men may predict the action of the courts” and flexibility in the resolution of conflicts - conflicts that are rooted in deep uncertainty about the future, between parties with unequal power and mismatched interests (Llewellyn, 1930). It is challenging because it can impede policy change.

Legal protections exist for property holders who are harmed through the negligence of government, e.g., failure of a duty to keep people and property safe, or are compelled to surrender some or all of their property in response to government action, resulting in a taking. The 5th amendment to the U.S. Constitution states that private property shall not “be taken for public use, without just compensation.” The 14th amendment extends this protection against public seizure of property to state and local government actions. Initially limited to physical possession of property, the notion of takings has been expanded through court action and legal precedent to include legislative or executive actions that “go too far” (Pennsylvania Coal Co. v Mahon, 260 U.S. 393, 43
S. Ct. 158, 67 L. Ed. 322 (1922)) and require individuals to “bear the public burden”
\( (Armstrong \text{ v US, 364 US 40, 80 S. Ct. 1563, 4 L. Ed. 2d 1554 (1960)) \) These are known as regulatory takings. Determining what is and is not a regulatory taking is an ongoing task for the American legal system. Government response to climate change, especially sea level rise, introduces new complications which threaten to submerge private property and existing public services (Byrne, 2010; Craig, 2010).

In cases like the flooding at Gallo’s restaurant, Miami Beach has clearly stated that it does not believe it is legally responsible for damages to private property. In emails, testimony, and other meetings city employees and elected officials state that raised roads will not send water from the public right of way onto private property. Private property owners are, under Miami-Dade county code, responsible for rain water that falls on their property.\(^4\) However, the law in Florida is far from definitive when it comes to drainage and local government liability (Wilkins, 2011).

Were Miami Beach legally responsible for incidental damages caused by raising public roads it could potentially face tort lawsuits, costing extra money and slowing adaptation efforts. Fortunately for Miami Beach, most local government actions, including negligence, are shielded by sovereign immunity – government’s privilege not to be sued without consent – under Florida State law, however inconsistent application by the courts has left some room for lawsuits (Bowley, 2015). Florida courts have found that changes in drainage that results in new flooding is not protected by sovereign immunity (Wilkins, 2011). Additionally, courts have distinguished between local government

\(^4\) For example, the city’s position on legal responsibility is stated in Miami Beach’s website in the “Flooding – Frequently Asked Questions” document: http://miamibeachfl.gov/RisingAbove/Default.aspx?id=90058, and in an email from City Commissioner John Aleman (john@johnaleman.com) March 15, 2017.
planning and operational activities that result in damages. Planning is always immune to lawsuits but negligent operation of stormwater infrastructure is not always covered (Wilkins, 2011). It could also be argued that a resident who supports adaptation including elevating roads could claim a breach of duty if the city did not raise a street to its planned minimum elevation of 1.1 meters (3.7 feet) NAVD. Potentially they could seek an injunction forcing the city to raise the street (Bowley, 2015). This duty of care argument has advanced further in other countries including Australia as a means of forcing unwilling communities to begin planning for climate change (Burkett, 2013).

Local governments interested in managing the legal risks of climate change can seek guidance from federal and state agencies. Presidential Executive Order 11988 directs federal agencies to take action to reduce the risk of flood losses and has been used to develop best practices and guidelines for floodplain management. In Florida, the 1985 Local Development and Comprehensive Planning and Regulation Act (Florida Statute §163.3161) requires Florida local governments to develop comprehensive development plans, reviewed by the state, and locally enacted. Plans in coastal communities are given objectives that include, “Limitation of public expenditures that

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5 NAVD 88 stands for North American Vertical Datum of 1988 and incorporates many elevation corrections from the previous standard National Geodetic Vertical Datum of 1929 (NGVD 29). In Miami Beach to convert from NGVD to NAVD 1.65 feet is subtracted from the NGVD elevation, e.g., 5 feet NGVD is equivalent to 3.35 feet NAVD. Miami Beach uses NAVD for public works and is converting the rest of the city’s departments, however the Florida Building Code is stated in NGVD. FEMA is also transitioning from NGVD to NAVD and discusses the challenge here: https://www.fema.gov/mmedi libary-data/20130726-1755-25045-0634/ngvd_navd.pdf

6 The Massachusetts Office of Coastal Zone Management advocates for local government adoption of No Adverse Impact land management practices to overcome legal challenges and provides support documents on its website: www.mass.gov/czm/stormsmart. The Florida Department of Economic Opportunity supports Adaptation Action Areas to increase resiliency. NOAA provides basic guidelines and case studies for managed retreat at: http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_retreat.html.

7 Executive Order 11988 was issued in 1977 and continues to inform the decision at agencies like Housing and Urban Development and Department of Transportation.
subsidize development in high-hazard coastal areas” and "Protection of human life against the effects of natural disasters” (Wilkins, 2011; Florida Statute §163.3177(6)(g)(1)(g), (h)). A major challenge for municipal government is deciding when and where to make public infrastructure investments in roads and utilities, as was seen in *Jordan v St. John’s County* where private property owners sued the county to provide service on a beach front road washed away by storm action (*Jordan v. St. John’s County*, 63 So. 3d 835 (Fla. Dist. Ct. App. 2011)).

Two legislative developments related to local planning indicate that communities like Miami Beach are beginning to receive support from state legislators in the planning of adaptation efforts. First, in 2014 the Florida Legislature gave local municipalities a tool to begin dealing with sea level rise in the form of Adaptation Action Area (AAA). These enable local governments to identify high risk areas in which behaviors that increase the risk of flood damage can be regulated. Three general approaches have been identified for these areas: protection, accommodation, and retreat. Coastal communities

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8 Adaptation Action Areas are defined in two sections of the Florida Statutes. F.S. §163.3164(1): Adaptation action area” or “adaptation area” means a designation in the coastal management element of a local government's comprehensive plan which identifies one or more areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning. F.S. §163.3177(6)(g)(10): At the option of the local government, develop an adaptation action area designation for those low-lying coastal zones that are experiencing coastal flooding due to extreme high tides and storm surge and are vulnerable to the impacts of rising sea level. Local governments that adopt an adaptation action area may consider policies within the coastal management element to improve resilience to coastal flooding resulting from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sealevel rise. Criteria for the adaptation action area may include, but need not be limited to, areas for which the land elevations are below, at, or near mean higher high water, which have an hydrologic connection to coastal waters, or which are designated as evacuation zones for storm surge.

9 The Florida Department of Economic Opportunity identifies three broad adaptation techniques:
   1) Protection - Protection strategies involve "hard" and "soft" structurally defensive measures to mitigate the impacts of rising seas, such as shoreline armoring or beach renourishment, in order to decrease vulnerability yet allow structures and infrastructure in the area to remain unaltered. Protection strategies may be targeted for areas of a community that are location-dependent cannot be significantly changed structurally (i.e., downtown centers, areas of historical significance, water-dependent uses, etc.).
in Florida including Broward County, Miami-Dade County, Ft. Lauderdale, Miami Beach and Satellite Beach are experimenting with how to use AAA guidelines within their comprehensive plans to limit spatial and temporal development (Houston Endowment et al., 2015). For example, Miami-Dade County is currently engaging homeowners, planners, hydrologists, and community activists in a process to create an adaptation plan for the Arch Creek Basin – a coastal neighborhood which regularly floods when high tides combine with heavy rainfall.

Second, in 2015 the Florida State Legislature modified local comprehensive planning authority to address flooding (Houston Endowment et al., 2015). Plans designed to “eliminate inappropriate and unsafe development in the coast areas when opportunities arise” are required to include “principles, strategies, and engineering solutions that reduce the flood risk” from the “impacts of sea-level rise” and “encourage the use of best practices development and redevelopment principles, strategies, and engineering solutions that will result in the removal of coastal real property from flood zone designations established by the Federal Emergency Management Agency” (Florida Statute § 163.3178(2)(f)).

2) Accommodation - Accommodation strategies do not act as a barrier, but rather alter the design through measures such as elevation or stormwater improvements, to allow the structure or infrastructure system to stay in place. Adaptation measures do not preventing flooding or inundation of the property but do protect the structure. Accommodation strategies may be suitable for location-dependent structure that could be changed to accommodate water, without compromising the use (i.e., bridge elevation, residential home elevation, downtown stormwater improvements, etc.).

3) Retreat - Retreat strategies involve the actual removal of existing development and possible relocation to other areas and the prevention of future development in these high risk areas. Retreat options usually involve the acquisition of vulnerable land for public ownership, but may also include other strategies such as transfer of development rights, purchase of development rights, rolling easements, conservation easements, etc.
Insurance companies, ratings agencies, and businesses are increasingly concerned about government inaction on climate change.\textsuperscript{10} They are beginning to incorporate climate risk into ratings and insurance products as they look for ways to push local governments to reduce their exposure to climate risks (Sundermann et al., 2014; Surminski et al., 2016). A new tactic uses unsuccessful breach of duty claims to nudge local governments to address their climate vulnerability. In 2014, Farmers Insurance sued 200 municipalities in the Chicago area for not properly preparing for damaging floods that led to insurance claims. The suit was dropped, but it received national attention and sent a signal to local governments (McCoppin, 2014). It is not yet standard practice for local governments to assess their climate risk exposure, but modelling techniques used by re-insurance to calculate catastrophic risks are beginning to be employed to assess the impact of local government adaptation on future climate related losses.\textsuperscript{11}

1.3 Climate Adaptation Barriers, Transitions, and Risk

Research on adaptation is a growing field concerned with helping shrink the gap between current policy and ‘optimal’ interventions that could significantly reduce future impacts of climate change (Ekstrom and Moser, 2014). Adaptation requires local governments to transition away from the status quo to new policies and management methods that can only be achieved if barriers to change are overcome (Eisenack et al., 2014). Adaptation drivers, barriers, and transitions can be analyzed through the lens of

\textsuperscript{10} The Geneva Association, an international think tank for the insurance industry, has a working group on extreme events and climate risk which has created a set of guiding principles that 68 leading insurance executives have endorsed that recognizes the risk of climate change and the need to integrate it into insurance products, https://www.genevaassociation.org/research/topics-sub-pages/climate-risk-subpage/.

\textsuperscript{11} On February 27, 2017 the British Consulate and the Miami-Dade Beacon Council hosted business leaders from the British re-insurance and risk management industry aimed at encouraging local governments in South Florida to be early adopters of their climate exposure assessment tools. The group included risk modeler RMS which provided analysis behind the 2014 Risky Business Report (Gordon, 2014)
risk. It provides a conceptual link between individual perceptions, vulnerability or exposure to climate change, scientific uncertainty, and government risk management decisions including flood protection and water supply management (Dobbie and Brown, 2014). Water is “a crucial constituent” of society and is a useful starting point to understand complex societal decisions (Bijker, 2012), like adaptation to climate change.

1.3.1 Climate Adaptation Experiments and Barriers

Climate change undermines the reliability of historic data, particularly in the water sector (Milly et al., 2008). As a consequence, to continue to provide the same level of flood protection and water supply, local governments must use water more sustainably. Attempts to shift from business as usual to a new climate adaptive normal based on continuous assessment and adjustment has been described extensively through case studies (Hornberger et al., 2015) and reviews (Biagini et al., 2014; Bierbaum et al., 2013b; Nordgren et al., 2016).

Experiments at the municipal level help identify effective, replicable solutions (Nevens et al., 2013) and have been championed as a way to pursue integrated water management, which takes a holistic approach to supply, quality, and flood management (Farrelly and Brown, 2011). Water management experiments, like all climate change choices, require collective action embedded in the institutions and societal structures of communities (Rayner and Malone, 1998). Context plays a significant role in determining how communities transition towards sustainable water management and whether or not experiments succeed or fail. Though individual case studies can be highly informative (Flyvbjerg, 2006), how you treat context determines the external validity of academic research attempting to draw comparative lessons from multiple adaptation case studies.
Case studies of climate adaptation require a longitudinal approach that views transitions as the result of the accumulation of knowledge gained while attempting to address barriers (Eisenack et al., 2014) through ‘clumsy solutions’ that are often more effective than optimal (Dilling et al., 2015).

Institutions act within existing pathways, and the uncertainty of climate change necessitates an iterative adaptation process that is never truly complete, constantly creating opportunities for problems to arise. These problems or barriers impede adaptation actions and can potentially be reduced or mitigated within a given set of conditions (Eisenack et al., 2014). Moser and Ekstrom (2010) developed a framework to identify common barriers and define categories within planned adaptation processes. It diagnosis barriers across spatial and temporal scales within predetermined phases of adaptation. Applying Moser and Ekstrom’s (2010) framework, two independent research groups, primarily using American (Bierbaum et al., 2013b) and European (Biesbroek et al., 2013, 2011) cases of adaptation categorized common barriers. These analyses resulted in similar and overlapping categories of barriers to local government adaptation (see Table 1.1). Both identify the need for leadership to drive urgency, financial resources, and climate information. Additionally, diverging risk perceptions (discussed further below), timescales, and institutional or jurisdictional priorities. These categories are descriptively helpful but are limited in their ability to model the dynamic, multi-layered reality of adaptation in which barriers arise unexpectedly.

Researchers recognize that climate adaptation is at its core adaptive and iterative, a process in which actors respond to pressures and dynamically interlinked barriers arise unpredictably (Eisenack et al., 2014). This highlights a shortcoming of Moser and
Ekstrom’s (2010) diagnostic framework. Because it is based upon a planned, idealized adaptation processes it fails to capture the full situational complexity including why barriers arise in some situations and not others. Therefore the necessary task now is to identify, in case studies, how barriers appear dynamically over time within the adaptation process (Eisenack et al., 2014). This requires longitudinal research on transitions, how policy and the use of new technology – including physical infrastructure, building codes, collaboration platforms, funding mechanisms, etc. – change over time through the iterative process of adaptation.

<table>
<thead>
<tr>
<th>US National Climate Assessment (Bierbaum et al., 2013b)</th>
<th>European Scholars (Biesbroek et al., 2013, 2011)</th>
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<tr>
<td>Lack of leadership</td>
<td>Motives and willingness to act</td>
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<td>Lack of resources</td>
<td>Lack of resources</td>
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<td>Available climate information</td>
<td>Lack of awareness and communication</td>
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<td>Fragmented decision-making</td>
<td>Institutional fragmentation</td>
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<td>Divergent risk perceptions and values</td>
<td>Strategic and institutional uncertainty</td>
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<td>Institutional constraints</td>
<td>Institutional crowdedness and void</td>
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<td></td>
<td>Conflicting timescales</td>
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Table 1.1: Categories of common climate adaptation barriers identified by American and European scholars. Similarities between the identified categories demonstrate a convergence of common problems.

1.3.2 Transitions

Transforming society requires that new technologies, physical and social, are implemented often before they can be fully proven (Wen et al., 2015). Technological transitions are socially constructed phenomenon, the result of a series of layered, culturally embedded decisions (Bijker et al., 1987). Studies of policy transitions identify two common change processes punctuated or fast and gradual or slow (Sabatier and Weible, 2014). Research on socio-technical transitions, which focuses on societal adoption of new technology or policy solutions, also identifies a multi-decadal, layered
process of transition with punctuated periods of accelerated change (Brown et al., 2009; Geels and Schot, 2007). Successful sustainability transitions often follow a relatively fast progression from problem identification to solution generation and implementation, followed by monitoring and reassessment (Kemp et al., 2007).

Time is a central component of transition in these literatures. How context accumulates over time is important for understanding climate adaptation, particularly for understanding the drivers of and barriers to change – or transitions – central to the climate adaptation process. Combining policy and transitions literatures in the context of climate adaptation at the project and local government level provides a structure for analyzing why some projects are effective and others are not.

Water is a useful frame or heuristic for studying transition and change in society (Bijker, 2012). As global and regional climate systems become increasingly unstable and unpredictable, water supply becomes less reliable. For example, flooding is likely to increase in many regions of the United States (Stedinger and Griffis, 2011). This poses a problem for water managers that must be solved by changes in institutional and legal structures at multiple levels of government (Corfee-Morlot et al., 2011; Craig, 2010). In other words, to sustain existing standards of living and safety while reducing pressure on environmental resources, governments and institutions will have to reconfigure themselves (Dobbie et al., 2016).

To be sustainable, new management must integrate management across geography, political structures, and traditional divides like water supply, flood protection, and wastewater treatment. This drive towards integration, if successful, will result in ‘Water Sensitive Cities’ that manage the regional urban water cycle in a holistic manner,
doing more with less (Brown et al., 2009), see Figure 1.2. Though the water sector is traditionally viewed as conservative (Brown et al., 2011) there is evidence that change is coming. Partial transitions have been documented in Melbourne (Brown et al., 2013), Los Angeles (Hughes et al., 2013), and Amsterdam (van Leeuwen and Sjerps, 2015).

![Figure 1.2. The transition to sustainable urban water management in an idealized water sensitive city (Brown et al., 2009).](image)

However, results need to be documented consistently across cases if researchers and practitioners are going to learn what interventions work and which can be transferred out of their specific context (de Haan et al., 2015; Hornberger et al., 2015). In a special issue of Environmental Innovation and Societal Transitions the editors argue the urban water sector can and should be used as a model for studying transitions, including climate adaptation, for three reasons (de Haan et al., 2015):
1. Urban water provides a comprehensive and representative context for exploring the dynamics of sustainability transitions.

2. There are rich, well-known examples of urban water systems having moved beyond take-off phase of a sustainability transition despite strong path dependencies and the sector’s typically risk-averse culture.

3. The established scholarship on urban water provides a solid scientific basis, which enables deep case studies that can make ample use of primary data.

1.3.3 Theories of Transition

Political scientists and policy scholars have long studied transitions, primarily under the name of policy change. Theories describe policy process and evidence supporting theories at different levels of governance and in a variety of venues (Weible et al., 2011), including in-depth case studies of water management (Sabatier et al., 2005). Punctuated Equilibrium Theory (PET) attempts to reconcile the general stability and incrementalism of the policy process with moments of sharp departure from the past (Baumgartner et al., 2014). It has received increased attention in the past decade from academics and practitioners, expanding from its initial application as a description of agenda setting in U.S. budgeting to the analysis of all types of national and state level policy (Eissler et al., 2016).

The “lurching” nature of United States federal policy making and physical scientist descriptions of negative and positive feedback within natural systems were inspirations for the development of PET. The central idea of PET is that institutions are stabilized by their conservative nature. Incentives to maintain existing policy create a negative feedback loop that prevents change. Dramatic, punctuated changes occur when
issues are reframed within institutions and amplify the problem posed by existing policy, creating a positive feedback loop and a sharp break from the formerly protected policy (Baumgartner et al., 2014).

Socio-technical transitions studies take a broader view of the question of how transitions occur. Researchers have developed a conceptual model in which three layers of activity interact on multiple stages over decades as societies adopt and integrate new technological solutions. The three socio-technical layers are niche level innovations, regime level changes, and broad landscape developments, see Figure 1.3 (Geels, 2002). At the niche level, small networks of actors introduce and test innovations. These networks function in a web of co-creation that feeds into the regime level as successes are identified and promoted. Regimes, often cities and agencies within a broader region, are ‘dynamically stable’ and relatively resistant to change but experience moments of accelerated change, typically on the scale of months and years – less than a decade. The landscape level realizes change on a much longer, multi-decadal timeframe. When studying transitions in a specific region and technological arena, like water management in a large city, regimes are exogenously influenced by landscape developments, e.g., change in national environmental policy, and exert their own influence on the landscape often through moments of accelerated change as governance is reconfigured in response to new technological developments, (Geels and Schot, 2007).

The theoretical, conceptual model of multi-level, multi-decadal transitions has led to the proposal that experimentation and demonstration projects should be seen as an important driver of water management innovation (Farrelly and Brown, 2011). This conjecture has been tested through case studies in Melbourne’s move towards integrated
management of its watershed (Rogers et al., 2015), experiments with ‘Room for the River’ projects that introduced new ways of accepting flooding in the Netherlands (van Herk et al., 2015), and through the implementation of “Urban Transition Labs” in cities across northern Europe (Nevens et al., 2013).

Figure 1.3. Multi-level diagram of layered socio-technical transitions describes the interaction between niche level innovations, regime level changes, and broad landscape level shifts (Geels & Schot, 2007).

Triple Exposure Theory is an emerging approach to the analysis of transition towards water sensitive cities that draws on both policy change theories and socio-technical transitions studies (Hughes et al., 2013). Hughes, Pincetl, and Boone (2013) use the transition towards sustainability within Los Angele’s notoriously complex water system in the 1990s and 2000s to analyze drivers and barriers to change. Building upon the feedback loops and dramatic shifts described by Punctuated Equilibrium Theory, they
identify three mutually reinforcing drivers: environmental (drought and uncertainty), regulatory (water delivery restrictions), and political (public and city-level increases in environmentalism) that motivated Los Angeles to overcome financial and institutional barriers in a transition toward water conservation and interagency collaboration.

**1.3.4 Applied Research on Transitions**

Prescriptive research applies and builds upon theories of change to suggest specific interventions that lead to successful transitions. Consistent with policy change theorists, these researchers recognize that responding to the physical and societal challenges posed by increased climate variability, requires *incremental* as well as *transformational* processes (Bierbaum et al., 2013b; Pelling, 2011; Rickards, 2013). Incremental adaptation occurs as a series of adjustments that maintain the basic structure of the existing system. They build on existing behaviors and actions to handle increased climate variability (Kates et al., 2012). Most adaptations currently adopted by American localities can be considered incremental. These include elevating homes, adjusting floodplains, changing building codes, and growing crops suited for more extreme temperatures (Bierbaum et al., 2013a).

Transformational changes, which include fundamental changes to systems and deviations from business as usual, are necessary for adaptation because climate impacts are more likely to be felt as a series of catastrophic events leading to policy and planning crises, rather than a steady transition from one state to another (Adger et al., 2012; Field et al., 2012). In highly vulnerable coastal areas like South Florida, the slow rise in nuisance flooding and the catastrophic impact of hurricanes are likely to lead to both
incremental and transformational adaptation actions. Hopefully incremental and transformational adaptations can be coordinated and benefit each other.

Transition Management proposes a normative four stage guide for successful planned sustainability transitions. Developed by a group of Dutch scholars and applied in the Netherlands across a number of sectors including energy, health care, and water management (Loorbach, 2007; Loorbach et al., 2015), it provides a conceptualization of how transitions progress through an iterative, adaptive process (Kemp et al., 2007). The four stages are:

1) Problem structuring, establishment of the transition arena and envisioning;
2) Developing coalitions and transition agendas (generating solutions);
3) Mobilizing actors and executing projects and experiments (implementation);
4) Monitoring, evaluating, and learning.

For example, the approach has been applied successfully to experiment with lowering levees and allowing limited flooding in the Dutch city of Dordrecht (Gersonius et al., 2016). This involved a shift towards managing how residents respond to flooding rather than just engineering a physical solution. Through a series of stakeholder interactions, a multi-layer safety approach was introduced that integrates emergency management, spatial planning, and flood protection to create a higher level of security without building a wall around the historic city and cutting it off from the river (van Herk et al., 2014).

1.3.5 Risk

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12 A similar five stage adaptation cycle has been proposed by the National Research Council (2010).
A risk is a negative future contingency – harm that could happen to something people care about. Risk is rooted in human values and how threats to those values are described and perceived by individuals, within groups of individuals, and between groups, i.e., communities (Boholm, 2015). Though not all decisions involve risk, many do, including Miami Beach’s decision to raise the streets of Sunset Harbour. When people make risky decisions in a considered way, to reduce the possibility of negative future outcomes, they engage in risk management (Slovic, 2000). Risk management is called upon to justify decisions, to guide investments, to create a sense of safety when putting our trust in complex technology like airplanes or vaccines.

Making risk central to decisions has made society safer and richer. However, the traditional approach to risk communication in which experts describe risks and advise non-experts who make decisions no longer works, if it ever did (Arvai, 2014). From a rational perspective, risk communication is about presenting objective and useful information, however risks are not processed entirely rationally. Instead they are constructed from a combination of cultural, emotional, psychological, and objective factors, creating a gap between object risk communicators and the decision makers they are trying to inform (Fischhoff, 1995). Distrust between decision makers and experts can also decrease the relevance of a risk and effectiveness of risk communication (Slovic, 2000, 1993). Trust in risk assessment increasingly comes down to trust in science.

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13 What exactly people mean when they talk about risk is contested – there are over twenty-five scholarly definitions of risk (Romero-Lankao et al., 2014). The Oxford English Dictionary defines risk as “[a chance or situation involving] the possibility of loss, injury, or other adverse or unwelcome circumstance.” Variants of risk used to describe commercial transactions in Italian and French were derived from the Latin *rescium* or *riscium* meaning danger or hazard, which may come from the older Arabic *rizq* which had multiple meanings including ‘provision, lot, portion allotted by God to each man’, ‘livelihood, sustenance’, ‘boon, blessing (given by God)’, ‘property, wealth’, ‘income, wages’, and ‘fortune, luck, destiny, chance’ ("risk, n." OED Online. Oxford University Press, January 2017. Web. 31 January 2017.)
Decreased trust in science as a neutral, authoritative arbiter of knowledge in contemporary society complicates the process of communicating and managing risks, especially political risks like climate change (Giddens, 1999).

Despite this challenge, risk is a common frame in the local, national, and international discussion of climate change, its impacts, and how to mitigate them. For instance, the Intergovernmental Panel on Climate Change’s (IPCC) most recent summary for policy makers describes the threat of climate change this way:

Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks. (IPCC, 2015)

It discusses adaptation and mitigation in terms of risk and cost reduction:

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term and contribute to climate-resilient pathways for sustainable development. (IPCC, 2015)

The IPCC describes climate risks in probabilistic, descriptive, and temporal terms. For example, the report states that it is very likely (indicating a 90-100% chance) that sea levels in the 21st century will rise at a faster rate than in the 20th century in more than 95% of the ocean. It describes key physical, biological, and societal risks for different regions of the world based on how likely they are now, in the near future (2030-2040), and long term (2080-2100) at 2°C or 4°C of warming (IPCC, 2015).

Scientific research is central to the objective definition of risk, including those produced by the IPCC. The central goal of science is traditionally conceived of as using
testable methods to describe the world as accurately as possible. That role has been made more complicated, more humble, and less linear than originally conceived, but no less important (Haack, 2003). This is particularly true when projecting the potential consequences of events that are difficult to experience, like a warming atmosphere, and confound the heuristics commonly used by people to make decisions (Weber, 2006).

Beginning in the 1970s, risk perceptions research has demonstrated definitively that “people respond to the hazards they perceive” and risk is complicated by individuals’ feelings of dread and control (Slovic et al., 1979). One of the most robust risk perception findings is that people are myopic and steeply discount or tend to avoid distant future risks, see Laibson (1997), Frederick et al. (2002), Weber et al. (2007), or Meyer and Kunreuther (2017). This and the recognition that emotions play a key role in the creation of risk preferences (Loewenstein et al., 2001; Slovic et al., 2007) has elevated the voice of behavioral and decision scientists in the discussion of the normative and real human response to climate change (Pidgeon and Fischhoff, 2011; Weber, 2010).

Risk perceptions are recognized as a key barrier to climate adaptation and mitigation (Biesbroek et al., 2013). For example, climate risks that are perceived as psychologically distant induce less worry and thus are less likely to motivate a response from individuals. Psychological distance can be temporal – future risks are less worrying than immediate risks, geographic – impacts are spread around the world, social – vulnerability is uneven across society, or driven by uncertainty – individuals are psychologically biased towards outcomes that are certain (Spence et al., 2012).

1.3.6 The Relational Theory of Risk
The Relational Theory of Risk (RTR) presents a promising new tool for analyzing risk perception and objective risk (Boholm and Corvellec, 2011). It identifies three components of risk: values, threats, and risk relationships that are necessary for an observer or interpreter to recognize a risk. Risk construction is performed by an actor or group of actors who observe the risk while situated within a particular context, such as launching a rocket, communicating the safety of a vaccine, or crossing a street. The theory was developed by Boholm and Corvellec (2011) as an analytical method to assist their interdisciplinary research in risk communication and risk management.\footnote{In attempts to explaining the Relational Theory of Risk, I have found these terms to be consistently confusing – even after carefully defining their meanings and justifying their use. Because of this, when discussing RTR I choose to use value instead of “object at risk” and threat instead of “risk object”. Despite the potential for confusion with common meanings, the familiarity of value and threat provides clarity and ease of understanding. Because the use of value and threat sacrifices the subtle specificity of identifying the components of risk as “objects” it is important to remember that the components of risk – values, threats, and relationships – are socially constructed artifacts that may or may not be objectively defined in a familiar way.}

A value, or “object at risk”, in RTR is anything considered at stake or capable of being harmed. Value can be described in symbolic, conceptual, economic, or whatever terms reflect an observer’s priorities. Value is expressly subjective and any normative measures of value can be recognized as relevant. A threat, or “risk object”, is any hazard or danger that can threaten a value. A threat’s potential for harm is not absolute. It only arises in the subjective connection to value through the framing of risk. Objects, such as cars, can be primarily considered positive but conceived of as threats in certain contexts such as attempting to cross a busy road or thinking about climate change.

Finally, a risk relationship\footnote{The Relational Theory of Risk has the potential to help overcome practical and theoretical problems of climate adaptation. It can proactively identify hidden sources of conflict or disagreement within a decision making process or retroactively uncover how a particular action, such as installing storm water pumps,} is the link or association between a value and a threat. Relationships do this by first highlighting a causal mechanism linking the value
and the threat that describes how the threat could harm the value. Second, it describes the contingent nature of the causal mechanism as something that is possible but that will not necessarily occur. This can be quantified or simply described. Third, the relationship is embedded in the cultural and practical context in which a risk is constructed, including who identifies the risk and their perspectives, intentions, assumptions, and knowledge (Boholm and Corvellec, 2014). Because values and threats are not fixed objects and have fluid meanings or associations, values can become threats and threats can become values depending upon who is observing or articulating the risk. In fact, one person’s value can

provided the intended protection but catalyzed another problem, such as residents becoming concerned about pumps polluting the natural waterways near their homes. It can also assist in the design of testable risk communication strategies capable of motivating behavior change. However, to do this the risk relationship identified in RTR needs to be further formalized. Because climate change is often framed as an array of risks potentially impacting vulnerable communities and ecosystems across the world, a formal extension of the Relational Theory of Risk to address climate change risk is needed.

Anthropogenic climate change is projected to lead to higher temperatures in the atmosphere and oceans, rising sea levels, changes in precipitation, and more powerful storms (IPCC, 2015). How these changes will impact communities and ecosystems is an active area of scientific research. The results are often reported as risks. For example, Hallegatte (2013) calculated actuarial flood damages in major coastal cities from 20 cm of sea level rise or subsidence and reported that, “with no adaptation, the projected increase in average [anticipated global flood] losses by 2050 is huge, with aggregate losses increasing to more than US$1 trillion per year”. Categorizing the components of this using RTR, the threat is increased flooding from climate change, the value is property in major coastal cities in dollars, and the risk relationship is that without adaptation sea level rise will increase the likelihood of losses to major coast cities.

I propose further dividing the risk relationship into three components: (1) timeframe, (2) uncertainty, and (3) pathways of impact. A timeframe is a representation of when a threat may occur, either an exact date such as 2050 in the example above or a time range such as 5-10 years. Uncertainty is a description of how likely the threat is to occur at the time identified, represented either probabilistic, e.g., 90% chance, or descriptively, e.g., very likely. Pathways describe how the threat will negatively impact the value. These include the scale of the impact, e.g., major coastal cities, and nature of the impact, e.g., US$1 trillion in annual losses from flooding. Pathways can also include contingent information about the future, e.g., “with no adaptation”, that may be necessary to fully describe the scenario in which the risk is situated.

I have also identified three additional categories that are helpful to include in the analysis of climate risks. First, observers are the individuals or groups that articulate or relate a specific risk. Every risk has an observer, and the set of possible observers is huge. They could be participants in a decision making process, climate scientists, politicians, citizens reading a report, or the audience for a television show on arctic ice. Second, many risks are articulated with a particular response or risk mitigation action in mind. In climate change these responses can be categorized as adaptation responses, mitigation responses, or both. Articulating the type of response is helpful because it is a potential source of conflict, e.g., subjects who see mitigation as the only viable response may oppose actions that include adaptation even when the core components of a risk are the same. Third, assigning responsibility for mitigating a risk is often compels a response, morally or legally (Kermisch, 2012). Assigning responsibility may motivate observers to construe risks in predictable or strategic ways, either highlighting or obscure their role in a response.
often be another’s threat and a single threat, such as sea level rise, can be linked to multiple values.

The theory has multiple climate related applications. Specific risk constructions can be extracted from examples of existing climate communication efforts, potentially helping to identify sources of success or failure. Within case studies of climate change decision making, consistent descriptions of how risk is formulated enables identification of differences between groups and changes over time. It enables cataloging of risks to test theory based hypotheses about the impact of factors such as societal differences and time on risk perception and risk management. It also creates a formal structure for linking actual and perceived vulnerability with actions. This is particularly helpful for wicked problems like climate change where solutions often instigate new, unanticipated problems or risks, complicating management of the original risk.

1.4 Overview of Chapters

The results of three original research projects are presented in the next four chapters. These describe sea level rise risk perceptions among South Florida, local government response in Miami Beach, and the novel role of third-party facilitator that has emerged in the Netherlands and may be able to help communities in a region accelerate their efforts to adapt to climate change.

Chapter 2 reports the results of an immersive online simulation that accelerates 348 South Florida homeowners thirty-five years into the future so that they can ‘live’ the effects of sea level rise. The results contain a mix of optimism and caution for the prospects of future adaptation. On the positive side over 75% of participants support bond issues to pay for adaptation, even as the costs of the measures and effects of sea level rise
increase over the years. Likewise, there is little evidence that politically conservative residents who normally have more skeptical views about climate change are any less inclined to support adaptation. On the negative side, the number of homeowner interest in moving out of the region increases steadily over time as the sea level rises, driven by an increase in worry associated with viewing more information within the simulation.

Chapter 3 describes the city of Miami Beach’s rapid pivot towards sea level rise adaptive stormwater management, beginning in 2013. This case study applies a framework using an extension of the Relational Theory of Risk to link urgency and adaptation barriers. It finds that facilitation coordinated within the Mayor’s Blue Ribbon Panel on Flooding and Sea Level Rise was essential for capitalizing on urgency, creating legitimacy for action, and overcoming barriers as they emerged during the initial period of accelerated change. Barriers were driven by new stakeholders entering the process after the city set its agenda and began implementing adaptation actions. Adaptation actions that address risks at multiple timescales, e.g., raising streets, were the most successful.

Chapter 4 identifies an overlooked role that has emerged during the recent transition in Dutch water management, the *neo-oliemannetje* (nee-o-lee-man-it-che): an expert who uses technical and political knowledge to catalyze policy change by working within and around existing hierarchies to promote risk taking and consensus decisions. *Neo-oliemannetjes* are a professional subset of Dutch policy entrepreneurs hired by governments or stakeholder groups to design and facilitate participatory water management processes. As third-party participants, they guide and legitimize stakeholder processes to accelerate policy change and adaptively implement integrated water
management solutions. Finally, in Chapter 5 a set of four practical recommendations are proposed for South Florida in its response to climate change and opportunities are identified for future research support the success of these recommendations through academic and practitioner collaboration.
Chapter 2

Homeowner Risk Perception

Using Simulations to Forecast Homeowner Response to Sea Level Rise
2.1 Perspective

Sea level rise is a threat to coastal communities around the world. Recent research suggests that destabilization of ice sheets in Antarctica and Greenland is likely to combine with other forces to cause a meter or more of sea level rise by 2100 (Carson et al., 2016; Church et al., 2013; Sweet et al., 2017). By 2025, it will be clear whether or not local sea levels have begun to accelerate away from historic rates sending us towards that future (Haigh et al., 2014). In response coastal cities will have to make substantial investments in flood protection or risk trillions of dollars in losses (Hallegatte et al., 2013a; Hinkel et al., 2014). Because of variations in local geology and the built environment, cities’ vulnerabilities differ. Some communities will have more options and more time than others to respond and adapt to rising sea levels. One obstacle they all face is overcoming the psychologically driven myopic tendency to focus on the present and avoid dealing with risks that feel distant because they are difficult to experience (Bazerman, 2006).

One location particularly vulnerable to the effects of sea level rise is South Florida, anchored by the densely developed Miami metropolitan area. The region rests on a porous limestone bedrock that limits the effectiveness of levee and pump systems as a means of dealing with flooding problems, such as those successfully used in cities that are already below sea level like Amsterdam and New Orleans (Hughes and White, 2014; Park et al., 2011). This geologic reality combined with high value real estate and continued growth mean that the region could have $3.5 trillion in exposed assets by 2070.

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16 The research in this chapter was conducted in collaboration with Robert Meyer and Kenneth Broad and will be published in Global Environmental Change under the title, Using simulations to forecast homeowner response to sea level rise in South Florida: Will they stay or will they go?
compared to $416 billion today (Hanson et al., 2011). Moreover, less than three feet (0.9 m) of sea level rise would permanently displace over 300,000 residents (Hauer et al., 2016).

If sea levels rise within the intermediate range of NOAA’s latest scenarios by 2050 (Sweet et al., 2017), annual flood losses in South Florida could exceed $25 billion. However, if adaptation investments are made to maintain current levels of flood protection annual losses could be reduced to $2.9 billion (Hallegatte et al., 2013a).

While proactive investments in flood protection would thus appear to make strong economic sense, such investments require taxpayers and city officials to see merits in spending money now to ward off a hazard that lies in the distant future—something many appear averse to doing (Buchanan et al., 2016; Hinkel et al., 2014; Lickley et al., 2014). Moreover, because the funding for improvements would need to come, in large part, from local real-estate taxes, adaptation may prove even more difficult if sea level rise spurs out-migration.

In this study we attempt to explore the likely future effects of sea level rise on the region’s adaptation efforts by reporting the findings of a novel online, interactive computer simulation in which 348 South Florida homeowners experience and respond to 35 years of sea level rise. The simulation allows participants to “live” in a future South Florida that is experiencing worsening effects of sea level rise, and where residents are being asked to support adaptation efforts through costly bond measures. As in a natural setting, participants learn about conditions by accessing online media, watching television news broadcasts, and hearing the views of local residents. As such, the simulation helps participants overcome temporal distance in an experimental setting to
produce a more realistic understanding of how individual homeowners and specific populations will respond to anticipated future sea level rise.

We emerge from the research with two sets of findings, one substantive and one methodological. Our major substantive finding is optimistic in the short-to-medium term. We find, for example, that a large majority – approximately 75% – of participants are supportive of government making adaptation investments both now and in the future. We also find little evidence that, as conditions worsen, residents will adopt a “head in the sand” approach to the threat and avoid information. While we do observe a reluctance by some participants to initially seek out scientific information about sea level rise, as conditions worsen all groups engage in learning about the threat and possible remedies. This short-term optimism, however, is tempered by a longer-term basis for concern. Although most participants express a willingness to stick it out while the effects of sea level rise are modest, when impacts are portrayed as more severe, as sea levels rise 18 inches by 2050, expressed interest in moving out of the region within five years increases sharply.

The second, methodological, finding is support for the use of immersive simulations as a tool for forecasting long-term response to environmental changes. The simulation reported here was developed using a new web-based software platform that allows the rapid development and deployment of immersive simulations in which participants virtually experience and respond to future scenarios. While illustrated here in the context of predicting long-term response to one environmental threat in one region, the approach holds considerable promise as a tool by which planners can foresee the
likely long-term consequences of policies designed to address climate change and other risks.

Below, we first provide background for the research by reviewing the specific challenges facing South Florida and the psychological barriers that may impede adaptation to sea level rise there and elsewhere. We then describe the simulation and our findings. We conclude with a discussion of the implications of the work for both the substantive problem of sea level rise planning in Florida as well as the broader problem of adapting to long-term environmental changes.

2.2 Background

Sea levels have been rising globally since the 1800s, contributing to increased flooding in coastal cities (Sweet et al., 2014). While the global rate of increase has been slow (about 3 mm/year), evidence suggests that the rate of sea level rise is increasing, and could increase exponentially by the end of the century (Haigh et al., 2014). Increased coastal flooding is already being observed in many areas, and the costs could be massive by 2100, including over $400 billion in lost home value in Florida alone (Rao, 2016).

As an example, since 2006 the city of Miami Beach has experienced an effective rate of seal-level rise of 9 millimeters a year from a combination of sea level rise and land subsidence, resulting in increased flooding (Wdowinski et al., 2016). In response, the city is in the process of investing $500 million over five years to elevate roads, install pumps, and reinforce sea walls against rising seas in select, high value areas (Flechas and Staletovich, 2015). It has also begun updating building codes and emergency management plans. Its response is supported by a regional network, the Southeast Florida Climate Change Compact, that has been advocating for a comprehensive regional
response to sea level rise since 2009 and has created a unified sea level rise projection to
guide decision makers, (see Figure 2.1; (Sea Level Rise Working Group, 2015)).

As a relatively small and wealthy community, however, Miami Beach is the
exception in terms of its active response to sea level rise and its financial capabilities to
do so. Spatial and socio-economic impacts will not be felt uniformly along the coast. For
example, poor populations are expected to have more trouble responding to increased
flooding (Chakraborty et al., 2014). Likewise, Florida’s regional real estate market is
significantly supported by overseas investment. If wealthy investors with homes in other
cities choose to leave first, that could lay the expensive burden of adaptation on middle
and lower income residents who do not have the option to leave.

Figure 2.1. Southeast Florida Climate Change Compact Unified Sea Level Rise
projections, adopted as guidance for planning by Broward, Miami-Dade, Palm Beach,
and Monroe Counties and used as the basis for the scenarios within our simulation
(Sea Level Rise Working Group, 2015).
2.2.1 The Psychology of Resistance to Preparedness

Given the threats posed by sea level rise, why are efforts to address the threat not more widespread? Although some communities’ limited financial resources play a role, we suggest that psychology may be an even larger factor. As real as the threat may be, its most severe impacts are thought to remain thirty years or more in the future, well beyond the normal planning horizons of developers or homebuyers. One of the most robust findings in studies of decision making is that people have difficulty making good decisions about prospective, uncertain outcomes, that lie in the distant future. They typically err by putting too much weight on that which is immediate and concrete over that which is temporally distant and vague (e.g., (Frederick, Loewenstein, & O’Donoghue, 2002), (Laibson, 1997). This myopic decision making is common with climate change because the impacts are uncertain, temporally distant, physically diffuse, and difficult to experience (Spence et al., 2012; Weber, 2016; Weber & Stern, 2011). One immediate consequence of such myopia is that residents and planners responding to climate threats will be prone to under-estimate the present value of investing in preventive adaptation. While everyone might benefit from addressing the distant threat, these benefits will pale next to the immediate psychic pain of paying for them.

An even more insidious consequence of myopia is that it fosters procrastination (Fischer, 2001). Even if both planners and residents fully accept the risk posed by rising seas, the fact that the increase in risk from one year to the next is small makes it easy to rationalize postponing action. A decision maker might have every intention to invest in protection but imagines that the pain of the expenditure will be easier to swallow next year, when it is temporally distant, as opposed to this year, when it is immediate. Of
course, come next year the same logical argument will return, leading to an endless cycle of delays.

This effect of delay will be exacerbated if residents are divided about the threat itself and how best to respond, which Americans are as a whole about climate change (Lee et al., 2015; Roser-Renouf et al., 2016). Those most skeptical of climate change are less likely to be moved by arguments for action, and are less likely to worry about climate change impacts (Whitmarsh, 2011). Moreover, such skepticism may be self-reinforcing. A well-known bias in decision making is that when individuals hold strong world views, they are prone to seek out information that works to confirm it – that is, engage in motivated reasoning (Kunda, 1990). This confirmation bias has been observed in experiments with climate skeptics, who have been found to actively avoid learning about climate change risks (Kahan et al., 2012). Additionally, longitudinal surveys indicate that the 25% of Americans who feel most engaged, proactively or skeptically, about climate change are more likely to fall victim to motivated reasoning, while the remaining 75% require experience to motivate them to learn (Myers et al., 2012). Thus, a skeptical resident who engages in motivated reasoning will, for example, be more likely to attend to news and media sources that express similar views and see nuisance flooding as a temporary inconvenience of nature, not a harbinger of future calamity. And a disengaged resident will wait until they experience flooding to pursue any information about rising seas.

Willingness to invest in protective action is also likely to be influenced by herd effects or social norms, a tendency to make decisions by imitating the behavior of others (e.g., Meyer and Kunreuther, 2017). The greater the collective skepticism about the threat
posed by sea level rise, or the more widespread the belief is that that the region can take a “wait and see” approach, the more widespread such beliefs may become within a community. For example, research by Lo (2013) on how homeowners decide whether to purchase flood insurance found that decisions were primarily driven by whether neighbors had purchased it. In essence, social norms trumped private calculations when making these decisions.

We should emphasize, however, that the same psychological factors that can impede investments in protection, can, in some cases, also work to foster it. For example, while motivated reasoning biases can work to reinforce prior skepticism about the threat, it can also work to reinforce affirmative beliefs. A resident who believes that the threat posed by sea level rise is real might be prone to see incidences of nuisance flooding as evidence that the worst predictions about sea level rise are beginning to be realized and spur vocal support for immediate action.

Consistent with this, past research has shown that those who have directly experienced harmful effects of hazards triggered by climate change are much more likely to be convinced of its existence (Moser, 2010; Reser et al., 2014) and more likely to support preventive measures (Akerlof et al., 2013; McDonald et al., 2015). In the same way, social norms can also serve as a positive agent for change. For example, they have been shown to increase peoples’ willingness to engage in pro-environmental behavior and energy conservation (Allcott and Rogers, 2014; Goldstein et al., 2008). The emergence of a social norm centered on concern about sea level rise and the risks it brings, e.g., community support for public flood mitigation investments could also work to increase individual support for action.
Finally, the degree to which individuals are willing to invest in protection may also be influenced by the nature and framing of the impacts themselves (Allcott and Mullainathan, 2010; Kidwell et al., 2013). Thus far, we have emphasized the personal economic impacts of sea level rise, but the environmental impacts on ecosystems like South Florida’s Everglades may be even more immediate and harder to address (Nungesser et al., 2015). However, whether presenting the impacts of climate change as economic or environmental will be more persuasive is unclear (Moser, 2014).

2.2.2 Immersive Simulation as a Tool for Forecasting Public Response

The above discussion provides an uncertain view of how South Florida will respond to the growing effects of sea level rise over the coming decades. On one hand, if residents in the region remain collectively myopic in their planning and skeptical about the seriousness of the risk, one might see limited support for preventive investments – at least until it is too late for them to be cost-effective. On the other hand, one might predict that as residents experience an increase in the observed effects of sea level rise (e.g., more nuisance flooding and higher taxes) they will work to galvanize support and allow the area to survive as a sustainable place to live well into the future.

Which of these scenarios is more likely to pan out? Addressing this empirically is difficult because it requires us to anticipate how residents will respond to environmental, economic, and social scenarios that are not yet in existence. While one could conduct surveys that ask residents today how likely they would be to remain in the area conditional on different future conditions (e.g., a three-foot rise in sea levels), survey approaches, while very useful in some cases lack face validity as a research tool for accurately portraying future behavior (Gilbert and Wilson, 2007; Trope and Liberman,
2003). Actual future responses to such conditions will be a function of a range of complex factors that are difficult to capture in simple what-if scenarios, such as the time path of change, social norms in the future, and how such an event would alter the living environment in South Florida.

In this research we attempt to overcome this measurement problem through the use of an immersive simulation that allows study participants to virtually “experience” 35 years of sea level rise in South Florida. In the simulation participants are able to learn about the effects of sea level rise as they would in a natural environment by reading different sources of on-line media, watching television programs, and hearing the views of local residents. The approach attempts to overcome the limitations of simple what-if scenarios by allowing participants to realistically control how they will experience the future. A climate skeptic, for example, may opt to learn about the evolving effects of sea level rise through the filtered lens of conservative news media (e.g., following Fox News), while someone who is already worried about climate change and sea level rise might seek out other sources, such as a concerned neighbor or an objective scientific report.

We might note the approach has its origins in the method of “Information Acceleration” that was first introduced as a means for forecasting demand for complex novel consumer products in marketing in the 1990s (Urban et al., 1997), and variations have more recently been applied to such environmental domains as water management (White et al., 2010) and hurricane evacuation and preparation responses (Meyer et al., 2014, 2013). The current work goes beyond prior applications, however, by extending the simulation over a multi-decade cycle of sea level rise and adaptation in which the future
that participants experience at any given point is dependent upon collective responses to
sea level rise at prior points.

2.3 Simulation Design and Data Collection

The study was conducted online using a web based application designed to accelerate participants through a future experience: sea level rise over a 35 year period. The platform was designed using a new web-based programming tool called Choice Flow, co-developed by two of the authors. It allows non-technical users to rapidly develop and deploy immersive “information acceleration” applications.17

The simulation was composed of five phases:

(1) Instructions and orientation – After consenting to participate, participants are given a brief description of the study. They are informed that they will be “accelerated” years into the future over the next twenty minutes and are asked to imagine themselves as they are now but in that future situation. The simulation begins with a series of images that depict Miami-Dade county as it appears today (2016 at the time of the study) and a brief narrative of the effect that sea level rise is currently having (e.g., minor nuisance flooding). Participants are then told that their main initial goal in the simulation will be to decide whether to support a County bond issue that would pay for flood-control measures (i.e., a sea level rise adaptation bond).

(2) Information gathering – After orientation, participants are taken to a virtual “living room” where they have the opportunity to learn more about conditions in South Florida and the bond measure by clicking on three different kinds of media:

17 For more details and availability see: https://www.deckspire.com/products/choiceflow/
television, neighbor testimonials, and online articles. When turning on the television they can view two brief news stories about flooding impacts and the sea level rise adaptation bond proposed by Miami-Dade County. Neighbor testimonials provided 10-30 second statements from worried and unworried residents. Online articles include an article on scientific fact (e.g., from the IPCC or NOAA), an agency impact statement (e.g., from FEMA or the Army Corps of Engineers), a neutral article about the adaptation bond from the Miami Herald, a less worried article on sea level rise from Fox News, and an alarmist article from either Huffington Post or Buzzfeed. The living room and sample media are illustrated in the screenshots shown in Figure 2.2.

(3) Decision making – After engaging as much or little media as they like, participants are asked to vote on the bond measure and answer a series of survey questions about worry, willingness to move, and willingness to invest in self-protective measures.

(4) Voting outcome – After indicating their vote, participants are taken to a new page that informed them of whether the bond issue passed or failed (randomly determined). The outcome of this vote then dictates the effects of sea level rise that participants experience in the next phase of the simulation (2030). If it passed the 2030 conditions are only modestly worse than those in 2016, but if it failed they are more significantly worse.

(5) Acceleration – After seeing the voting outcome participants are “accelerated” to the next time point, 2030. To make the passage of time appear more realistic, the acceleration phase involves viewing a sequence of online newspapers from 2018,
2022, and 2028 that depict technological advances and environmental changes that are occurring due to sea level rise in South Florida.

After the 2030 outcome is revealed phases (2) through (4) are repeated again, this time for 2050.

![Screenshot of the living room simulation environment (upper left) with examples of each media type (clockwise from the upper right): TV, online article, and neighbor testimonial.](image)

**Figure 2.2.** Screenshot of the living room simulation environment (upper left) with examples of each media type (clockwise from the upper right): TV, online article, and neighbor testimonial.

### 2.3.1 Experimental Design and Measures

The simulation studied responses to the effect of social norms, rate of sea level rise, and framing on decision making using a factorial design in which three factors, or variables, were manipulated at two levels each (see Figure 2.3).
(1) Passage or failure of the 2016 bond measure, to observe the impact of social norms and the willingness of others to pay for adaptation when considering the subsequent bond in 2030.

(2) Rate of sea level rise in 2030, fast (10 inches) or moderate (3 inches).

(3) Framing of the impact – i.e., environmental or economic, from 18 inches of sea level rise in 2050 (a high sea level rise scenario).

Study design (8 conditions)

Figure 2.3. Experimental design includes three manipulations with two conditions each introduced one at a time in 2016, 2030, and 2050.

Two types of response measures were collected at each time period. First, at the conclusion of each section participants were asked to complete a series of ratings scales that elicited: 1) their degree of worry about sea level rise; 2) their willingness to move out of the region; 3) their willingness to undertake self-protective actions like elevating a home or purchasing additional flood insurance; and 4) the aspects of sea level rise that formed their greatest source of worry. Second, in addition to these rating-scale responses, we gathered measures of information use that include when and how often each type of
media (TV clip, online article, or neighbor testimonial) is clicked and time spent consuming that media. Finally, at the conclusion of the study participants were posed with a series of socio-demographic questions such as age and income as well as questions about political orientation. The full set of gathered measures and scales is summarized in Appendix A.

2.3.2 Data Collection Procedure

Between March 29 and April 12, 2016, a representative sample of 348 (206 female) homeowners from four Southeast Florida counties were recruited through Pureprofile, a third party panel provider. Recruits were offered a nominal fee (<$10) to participate in a 20 to 25 minute online simulation (median time 23.4 minutes). As a quality control, 158 participants who completed the survey in less than 9 minutes and/or clicked on less than two pieces of media were discarded. This discard rate was within the normal range for this panel, included in our contract with the panel provider.

The sample was recruited by the panel provider to resemble the census demographics of Miami-Dade, Broward, Palm Beach, and Monroe Counties. A few differences from census data appear to reflect the bias of homeownership towards an older, wealthier, whiter, better educated population. The age of respondents was roughly evenly split between those 45 years-old or older (185) and those below 45 (163). All respondents were homeowners when they signed up with the panel provider, however when asked for their current living situation 4 said they were renters and 2 selected ‘other’.

\[\textsuperscript{18}\] Note that participants were given the option to not respond to individual questions, so some groups do not add up to 348.
The sample had higher educational achievement than the general population: 7 attended some high school, 33 were high school graduates, 92 attended some college, 139 were college graduates, 27 pursued some post-graduate studies, and 46 had obtained a masters or Ph.D.

The sample was also diverse in income, ethnicity, and political views. The median income of the sample was above the region’s median, with 34% of the sample indicating that they earned $45,000 or less (low income), 39% earning $45,001 to $80,000 (middle income), and 27% earning over $80,000 (high income). 80% of respondents self-reported as white (34% Hispanic), 10% as black or African American, 3% as Asian, and 7% as other or multiple groups. In terms of political views, on a 1-7 scale of increasing conservatism, 31% of respondents were liberal (less than 3.5), 31% centrist (3.5 to 4.5), and 38% conservative (greater than 4.5).

2.4 Results

We divide our results into three phases. First, we provide an overview of the main findings by describing how two key response measures—support for the bond issue and intentions to move—varied in response to our three experimental manipulations. We then explore how these responses were conditioned by socio-demographic and other characteristics of the participants. We conclude by exploring the patterns of information gathering revealed by participants—data that can provide deeper insights into the decision-making processes that led to the responses.

2.4.1 Support for Adaptation Bonds

In Figure 2.4, we plot the mean percentage of participants who voted in favor of bond issues supporting sea level rise adaption measures by year and rate of sea level rise
in 2030, a low-rate of 3 inches versus a high-rate of 10 inches. The figure yields what might be seen as a surprising result: support for the measures was uniformly high (over 75% support) across all time periods and sea level rise rate conditions. While there was a nominal tendency for support to be higher in the high-rate condition (79% versus 73% in 2030) the effect did not approach standard levels of significance in a repeated-measures ANOVA (F(1, 340)=1.29, P>0.25). Hence, a hypothesis that support for investments in adaptation might decline in future years as the effects of sea level rise is strongly rejected by the data.

![Bond support by year](image)

Figure 2.4. Percentage of respondents voting for bond measures at each time period, indicating no significant difference between the High and Low sea level rise conditions.

To better understand the basis of this constant support, we analyzed the percentage of participants who switched their votes from one period to the next. The goal of this analysis was to see whether the stability was due to all participants maintaining
constant attitudes over time, or a result of switching, where decreases from those who stopped supporting bond measure in one year are compensated for by gains from new supporters. In Figure 2.5 we plot the percentage of participants switching their vote between 2016 and 2030, and those switching between 2030 and 2050. The data provide support for the latter explanation for the stability in mean voting. From 2030 to 2050, 30% of participants switched support, for or against, the bond, significantly more than from 2016 to 2030 ($\chi^2(1)=80, p<0.001$). The direction of switching, however, was equally balanced; i.e., the percentage of participants who terminated their support after seeing the worsening conditions was matched by the percentage who added their support.

**Changes in bond support over time**

![Changes in bond support over time](image)

Figure 2.5. Count of participants switching their support for bond measures from 2016 to 2030 and 2030 to 2050.

### 2.4.2 Intentions to Migrate and Expressed Worry

The robust willingness of participants to support bond measures regardless of the severity of sea level rise conditions, however, was not reflected in their willingness to
remain as residents of South Florida as conditions worsened. To see this, in Figure 2.6 we plot mean intentions to move on (a 7-point Likert scale) as a function of year and sea level rise. Between 2016 and 2030 there is a 0.5 point rise in the mean stated intention to move ($M=4.1$ v $4.7$, $F(1,674)=18.3$, $P<0.001$), there is another 0.6 point increase between 2030 and 2050 ($M=4.7$ v $5.3$, $F(1,663)=17.2$, $P<0.001$). In addition, as willingness to move increases over time, the percentage of participants who intend to leave *within the next five years* increases from 18% in 2016 to 41% in 2050, when sea level rise is portrayed in its most extreme state.

![Interest in moving by year](image)

Figure 2.6. Mean interest in moving out of the region in each time period (2016, 2030, 2050) with standard error bars on a 1 to 7 point Likert type scale of increased interest.

Likewise, we observe a marginally significant effect of the rate of sea level rise in 2030 on intentions to move. In Figure 2.7, we plot the difference in move intention between the two 2030 sea level rise scenarios, 3 inches versus 10 inches. As expected
intention to move is greater when sea levels rise faster, though the mean effect is not statistically significant (M= 4.5 v 4.9, F(1,332)=2.5, p>0.12).

One possible explanation for the marked increase in move intentions over time, of course, is that it could have been driven by factors other than the observed effects of sea level rise. For example, looking 35 years into the future, participants may have imagined that by that point they would have moved due to job changes, etc., regardless of environmental conditions. To address this, in Figure 2.8 we plot mean ratings of worry about sea level rise as a function of year and severity. The data shows that increases in worry closely paralleled increases in move intentions: there was a nominally significant 0.3 point increase in worry between 2016 and 2030 (M=4.8 v 5.1, F(1,5.1), p<0.05), followed by another significant 0.3 point increase in worry between 2030 and 2050.

Figure 2.7. Mean interest in moving by sea level rise rate in 2030 with standard error bars on a 1 to 7 point Likert type scale of increased interest.
Similar to move intentions, a higher rate of sea level rise in 2030 is associated with greater worry (M= 4.9 v 5.2, F(1,319), p<0.1). Additionally, there is a positive correlation between worry and observed move intentions that increases over time from 0.49 in 2016 (r(300)=0.49, p<0.001) and 0.66 in 2030 (r(300)=0.66, p<0.001) to 0.71 to 2050 (r(300)=0.71, p<0.001). Hence, the data are consistent with the increased expressed intentions to move in 2030 and 2050 as being induced by increased worry about the effects of sea level rise rather than other factors.

Differences in social norms, i.e., passage or failure of the 2016 bond, has no effect on intention to move (M=4.7 v 4.7, F(1,332)=0.01, p=0.9) or worry (M=5.0 v 5.1, F(1,319)=0.5, p=0.48) in 2030. Likewise, framing the problem as economic versus

Figure 2.8. Mean worry about sea level rise in each time period (2016, 2030, 2050) with standard error bars on a 1 to 7 point Likert type scale of increasing worry.
environmental has no impact on intention to move \( (M=5.4 \text{ v } 5.2, F(1,329)=0.78, p=0.38) \) or worry \( (M=5.5 \text{ v } 5.3, F(1,310)=1.6, p=0.21) \) in 2050.

### 2.4.3 Individual Differences in Response to Sea Level Rise Scenarios

To investigate whether responses to sea level rise were homogeneous within the sample, we explore the degree to which the above results vary as a function of the political affiliation, age, and income of participants. Based on our earlier discussion, for example, we might expect participants who are more conservative in their political orientations to be both less likely to support bond measures and be more intent on staying in the area regardless of worsening conditions. More ambiguous, however, were the likely effects of age and income. On one hand, because of their more limited mobility and resources one might expect to see higher degrees of worry and a greater desire to move from the area among more vulnerable populations who are likely to experience more impacts and have a harder time responding, including young and low income homeowners. On the other hand, these same constraints could produce the opposite response: a greater intention to persist and avoid learning about risks due to a limited ability to move.

To explore these issues, in Figure 2.9 we first plot intentions to move by year as a function of aggregate political affiliation. Political affiliation was calculated by averaging responses to individual measures of social, economic, and political identity on a 1 to 7 scale of increasing conservatism. Beginning in 2016, centrists \( (n=125) \) have less interest in moving \( (M=3.7 \text{ v } 4.2 \text{ v } 4.5, F(2,318)=5.3, p<0.01) \) and less worry \( (M=4.5 \text{ v } 4.7 \text{ v } 5.1, F(2,302)=3.1, p<0.05) \) than conservatives \( (n=112) \) or liberals \( (n=90) \). In 2030 and 2050 all three groups report increased intentions to move \( (2030: M=4.3 \text{ v } 4.8 \text{ v } 5.1, F(2,311)=4.8, \)
p<0.001; 2050 M= 5.1 v 5.2 v 5.8, F(2,309)=4.5, p<0.05) and worry (2030: M=4.9 v 5 v 5.4, F(2, 301)=1.82, p=0.16; 2050 M= 5.1 v 5.3 v 6, F(2,291)=6.2, p<0.01) with liberals consistently leading other subgroups. In terms of voting, all three subgroups consistently support bond measures at rates near or above 70%, centrists at slightly lower rate than liberals and conservatives in 2016 (M= 71% v 77% v 79%) and 2030 (M= 69% v 83% v 75%) but at the same rate in 2050 (M= 78% v 75% v 76%). An ANOVA of voting by year and affiliation over all three time periods indicates no significant difference in voting due to affiliation (F(2,959)=1.57, p=0.21).

In Figure 2.10 we divide participants into two groups by age, young (under 45 years old) and old (45 years and over) and plot mean intentions to move. Young homeowners have a measurably greater intention to move in 2016 (M=4.5 v 3.7,
F(1,340)=16.9, p<0.001), 2030 (M=5 v 4.5, F(1,332)=5.7, p<0.05), and 2050 (M=5.6 v 5.1, F(1,329)=4.7, p<0.05). Both groups follow the familiar trend of becoming more interested in moving and more worried over time (2016: M=4.9 v 4.6 F(1,322)=2.8, p<0.1; 2030 M=5.3 v 4.8, F(1,319)=6.1, p<0.05; 2050: M=5.6 v 5.3, F(1,310)=1.9, p=0.17). As with political affiliation, support for bond measures is constantly high across groups, above 73% for both young and old homeowners.

![Interest in moving by year and age](image)

Figure 2.10. Mean interest in moving out of the region in each time period (2016, 2030, 2050) by age (under 45, 45 and older) with standard error bars on a 1 to 7 point Likert type scale of increased interest.

We plot intention to move, in Figure 2.11, by three income groups: low (<$45,000/year), middle ($45,000-80,000/year), and high (>80,000/year) and find a possible vulnerability among middle income homeowners in South Florida. Middle income homeowners are less interested in moving than their neighbors (2016: M(low,
middle, high)= 4.1, 3.8, 4.4, F(2,338)=1.9, p=0.15; 2030: M=4.9, 4.4, 4.9 F(2,330)=3, p<0.1; 2050: M=5.4, 5.0, 5.5, F(2,327)=2.25, p=0.11).

This difference in move intention appears to be driven by significantly less initial worry among middle income homeowners in 2016 (M=4.8, 4.4, 5.1, F(2,320)=4, p<0.05) and 2030 (M=5.3, 4.7, 5.2, F(2,317)=3.6, p<0.05) before they begin to catch up with their peers in 2050 (M=5.5, 5.2, 5.6, F(2,308)=2, p=0.13). Like we see with other groups, support for bonds is consistently high, above 70% in every time period, though middle income homeowners are consistently less supportive.

Figure 2.11. Mean interest in moving out of the region in each time period (2016, 2030, 2050) by annual income (lower: <$45,000, middle: $45,000-80,000, upper: >$80,000) with standard error bars on a 1 to 7 point Likert type scale of increased interest.
2.4.4 Information Search and Participant Engagement

The Choice Flow platform allows participants to control their experience of the simulation and gives researchers insight into how participants pursue information. By measuring how participants engage with a variety of media sources we can see how information use changes throughout the simulation and look for evidence of confirmation bias. In Figure 2.12, we plot the percentage of all participants who click on each type of media (TV clips, online articles, and neighbor testimonials) in each time period (2016, 2030, 2050). Overall media consumption declines in each successive time period, an unsurprising result as participants use the first time period to orient themselves within the simulation. Additionally, the rank order of media type consumed is constant over time, indicating a preference for TV over online articles and neighbor testimonials.

One important insight that can be gained from these data is whether participants selectively sought information in the simulation in a manner that served to reinforce their worldview about sea level rise and its effects; i.e., display motivated reasoning or confirmation bias. To explore this, in Figure 2.13 we plot time spent viewing all types of media by year and pre-simulation worry about sea level rise. Because the simulation clearly presents sea level rise as a threat to South Florida, if confirmation bias were present we could expect those who are least worried to spend the least amount of time gathering information. We find the opposite is true. Participants who report the lowest level of pre-survey worry (1-2 on a 7 point scale of increasing worry) spent more time than those who report moderate per-survey worry (3-5) or high worry (6-7). The only suggestion of confirmation bias is among participants reporting high pre-survey worry who stop gathering new information by 2030 – when the median high worry participant
spent less than 20 seconds consuming media compared with 48 and 77 seconds for moderate and high worry participants. In 2030, 69% of high worry participants indicate a strong interest in moving, compared with 34% and 33% of the moderate and low worry participants, which suggests a rationale for disengagement and a problem for South Florida leaders wanting to convince this group to stay.

Additionally, limited evidence of confirmation bias is present when media consumption is analyzed by political affiliation. 54% of Conservatives click on Fox News in 2016, more than liberals (41%) or centrists (42%). However, conservatives, centrists, and liberals click on scientific reports and unbiased Miami Herald articles at the same rate in every time period. They each click on Fox News at approximately equal rates in 2030 (40%, 39%, 37%) and 2050 (33%, 33%, 29%). Similarly, there is little evidence that

Figure 2.12. Percentage of participants who engage with each source of media (television, online articles, and neighbors) at least once in each time period (2016, 2030, 2050).

Additionally, limited evidence of confirmation bias is present when media consumption is analyzed by political affiliation. 54% of Conservatives click on Fox News in 2016, more than liberals (41%) or centrists (42%). However, conservatives, centrists, and liberals click on scientific reports and unbiased Miami Herald articles at the same rate in every time period. They each click on Fox News at approximately equal rates in 2030 (40%, 39%, 37%) and 2050 (33%, 33%, 29%). Similarly, there is little evidence that
participants pursue confirmatory information by only clicking on neighbors who reflect their own opinions.

Figure 2.13. Time spent consuming media in each time period (2016, 2030, 2050) by worry (High, Moderate, Low) about sea level rise before participating in the simulation.

2.5 Discussion

As sea levels rise, the future of densely developed coastal communities like South Florida is neither certain nor secure. In a worst case scenario, rising seas combined with myopic attitudes towards investing in adaptive flood protection could lead to a downward spiral of real estate disinvestment and loss of tax base, undermining the ability to adapt and other vital services as residents decamp for higher ground outside the region. The question is, will communities proactively invest in sea level rise adaptation without inciting a loss of confidence in public works and a widespread abandonment of properties?
This immersive simulation indicates that proactive investment is viable over the next three decades, but communities can and should begin as soon as possible. By allowing homeowners to control their own experience within a simulated future, we demonstrate that engaged learning and experience provide a way to accept the risk of sea level rise and overcome psychological barriers that can get in the way of serious climate adaptation efforts. When South Florida homeowners begin to actively learn about threats posed by sea level rise, and when the impact of those threats become tangible rather than speculative our results suggest they will become concerned. And individuals who are concerned about sea level rise and climate change are more likely to take proactive steps to protect themselves and their community.

Within our simulation, a large majority of South Florida homeowners, over 75%, support higher taxes to pay for climate adaptation, now and into the future. However, our data contains a cautionary warning for policy makers and planners. Less than 25% of South Floridians in our sample are currently concerned or worried about sea level rise. Worry steadily grows as they experience the impacts of moderate to high sea level rise, 18 inches over the next 35 years, and that growing concern appears to increase homeowners’ willingness to move out of the region. Alarmingly, this is particularly true for high income individuals who have the greatest ability to pay for expensive adaptation investments through increased real estate and other luxury taxes.

We are encouraged to find that, in this sample of South Floridians, assumptions about the intractability of ideological divisions do not hold. In our study, centrists not conservatives are the least worried about sea level rise and the least willing to take the major step of moving. Similarly, middle income homeowners, who may have the most to
lose because a large portion of their wealth is tied to their home, are less worried and less interested in moving than their neighbors. Due to South Florida’s economic stratification, this could have important implications for suburban middle class bedroom communities, many of which are focused on attracting new development and have not begun to address sea level rise.

Despite differences between demographic populations, we find that the response to sea level rise over time is more uniform than divided. Though individual groups begin at different levels of worry, as they engage with the simulation every type of South Floridian appears to become more worried and more willing to respond to sea level rise by taking self-protective actions or moving as they learn about and experience the impact the ocean rising 18 inches. Additionally, across all subgroups large majorities, over 70%, vote to raise taxes so that government can make adaptation investments.

The temporal and political challenges of climate adaptation are well documented. The results of this study, along with recent work that suggests simply communicating the consensus nature of climate facts, in our case, in an immersive and experiential format, can help people avoid biases like myopia and motivated reasoning (Myers et al., 2015; van der Linden et al., 2017). Two suggestions emerge for local policy makers and educators. First, work to communicate confidence in the possibility of future sea level rise scenarios with simple, clear facts about how your community and daily life could be impacted. Second, give citizens an opportunity to actively investigate those future scenarios through multiple sources of information: visuals, immersive simulations, scientific reports, stories, coastal flooding tours, and testimonials.
One additional contribution of the work is to illustrate how immersive simulations can be used as a tool to study behavioral intentions for environmental scenarios that lie in the distant future. At the conclusion of the simulation participants were invited to comment about their experiences, and these provided at least anecdotal evidence that it not only helped them to imagine being transported into the future but also allowed them to better understand the consequences of sea level rise. Representative comments include:

- “This simulation really brought home the real problem that south florida is having and will encounter in the near future. Now is the time to act and have steps in place to correct and work with this problem.”
- “I enjoyed this survey, it’s a real eye opener on how my life and livelihood will be in the future. The last [scenario] is the most disturbing, I really never have plans on leaving south florida but I realize that things are about to get more expensive for me and my family.”
- “This is very great survey that paints a picture nicely on things to come…It was very informative, the fact that it shows me how the future of South Florida could look if water continues to raise and worsen.”

Future studies using the Choice Flow platform or similar simulation tools could benefit from more in depth follow up with a smaller focus group. The simulation itself may be an effective educational tool to inform real life decision making. Combined with a rigorous follow up it could test if engaging with a realistic future sea level rise scenario leads to permanent changes in attitudes and behaviors. Additionally, the non-effect of traditional experimental manipulations like framing suggest that future simulation studies can keep manipulations to a minimum and instead use resources to focus on creating rich
scenarios and environments in which participants actively curate their own experience. Thus, widespread use of simulation experiences, including the incorporation of 360 video within augmented and virtual reality, like the Sustainable Behaviors project at Stanford’s Human Interaction Lab\textsuperscript{19}, have the potential to increase individuals’ ability to engage with future climate risks.

The results of this research demonstrate that homeowners and other citizens are capable of imagining a future in which sea levels are rising much faster than today and are willing to support proactive adaptation. If they are engaged by local leaders sooner rather than later, communities will be able to invest to mitigate the impacts of sea level rise and homeowners will stick around. If citizens become engaged too late for those investments to be made and the costs of sea level rise defrayed, communities like South Florida are likely to see a fairly large exodus in a short period of time once the actual impacts and large infrastructure bill come due. Further this departure could be led by the investment class, the service class, and younger residents – leaving middle income homeowners to foot the bill for rising sea levels as their property values stagnate or fall. That would be economically and socially devastating.

\textsuperscript{19} https://vhil.stanford.edu
Chapter 3

Urgency, Barriers, and Risk in Accelerated Climate Adaptation

The Case of Miami Beach
3.1 Overview

Rolling Stone published “Goodbye, Miami” (Goodell, 2013), in June 2013. The article detailed the threat of sea level rise in South Florida – the most economically vulnerable region in the world to rising seas (Hallegatte et al., 2013a). In it, the City of Miami Beach was criticized for adopting a $200 million stormwater master plan that claimed to be climate adaptive but in reality, relying on gravity drainage, was functionally ineffective when sea level rose over 0.15 meters (0.5 feet) (Goodell, 2013), possible within 15 years (Sweet et al., 2017). Recalling the days after the Rolling Stone article appeared – in the middle of a contested mayoral election – the city manager said, “All of a sudden my job security [was] dependent upon how I deal with a major geological and hydrological event in the history of the Earth” (notes Southeast Florida Climate Leadership Summit, October 1, 2014). Urgency to address flooding and sea level rise propelled a new mayor into city hall and sparked a policy transformation, including a five-year $500 million investment in stormwater infrastructure, that has made Miami Beach an international example of climate adaptation. Despite initial opposition, the City has convinced County and State partners to invest in street-raising projects as Miami Beach works to sustain its adaptation efforts and identify long-term solutions.

Miami Beach is a special case, foreshadowing the challenges many other cities will face as sea level rise accelerates. One of only a few municipalities in the United States to have implemented comprehensive climate adaptation measures (Hughes, 2015), it is a city of 90,000 residents on seven square miles of natural and manmade barrier islands off the southeastern coast of Florida. Founded in 1915 as a real estate investment

20 Analysis for this chapter was conducted in collaboration with Jessica Bolson and will be submitted for review under the title, Urgency, Barriers, and Risk in Accelerated Adaptation: The Case of Miami Beach.
and vacation spot, it is now an international tourist destination with total real estate values in excess of $30 billion, including the largest intact art deco district in the world (City Manager, 2016). The entire city is less than 3 m (10 ft) above sea level, and the vast majority of development is built less than 1.8 m (6 ft) above sea level. Flooding from heavy sub-tropical rains, storm surge during hurricanes, and seasonal high tides has always been an issue. It is a global destination for tourist and real estate investors, perhaps the most iconic part of South Florida. However, in many ways it is like other small cities attempting to deal with the threat of climate change. A confluence of events was needed to push it towards adaptation. In its transition from laggard to aggressive implementation of new adaptation measures, Miami Beach had to disrupt institutional and community norms. In under a year it identified risks, proposed solutions, and overcame barriers\textsuperscript{21} to successfully implement solutions.

This chapter describes the mechanisms that enabled Miami Beach to rapidly transition towards climate adaptation. It is divided into four sections. Following the introduction, Section 3.2, introduces a new framework that uses risk to relate urgency to barriers in cases of adaptation. Section 3.3 presents the case of Miami Beach, focusing on an accelerated period of policy change from late 2013 to 2015. Finally, Section 3.4 draws conclusions, makes recommendations for practitioners in cities experimenting with climate adaptation, and discusses future research opportunities.

Climate adaptation is a messy process. Decisions are contextual, variables interact, and theories of what leads to successful adaptation\textsuperscript{22} are difficult to test (Dilling, 2013).

\textsuperscript{21} Adaptation barriers are “obstacles that make adaptation less efficient, less effective or may require changes that lead to missed opportunities or higher costs” (Eisenack et al., 2014).

\textsuperscript{22} Successful adaptation effectively reduces climate risk through efficient and equitable investment of resources (Neil Adger et al., 2005).
2015). Because adaptation is preventive and ideally proactive, measuring the concrete outcomes of adaptive policy is a challenge (Dupuis and Biesbroek, 2013). It may be more useful to extract lessons from the experience of cities like Miami Beach by studying the mechanisms that characterize accelerated adaptation. Doing this requires new methods with a “specific focus on the interdependency and dynamics of barriers” to and drivers of adaptation (Eisenack et al., 2014).

To analyze the interdependencies and dynamics of climate adaptation in Miami Beach, the urgency, barriers, and risk (UBR) framework is introduced. It relies on the Relational Theory of Risk, which defines risks as perceived relationships between hazards and values, (Boholm and Corvellec, 2011) to connect urgency and barriers over time within the adaptation process. Risk is a unifying concept in the study of urban adaptation (Corfee-Morlot et al., 2011; Romero-Lankao et al., 2014), and managing future risk is the goal of climate adaptation (Hunt and Watkiss, 2011). The origin of proposed solutions, adaptation actions, the appearance of barriers, and facilitation of the City’s response are traced through data collected during the accelerated period of adaptation, including participant observation, document analysis, and interviews. Using the UBR to understand how barriers interact, conclusions are drawn about how urban areas can support long-term planning for climate change while managing immediate short-term challenges.

From the case of Miami Beach three takeaways are identified: (1) Barriers appeared towards the end of the agenda setting phase and early in implementation, when newly engaged stakeholders recognized and opposed specific adaptation actions. (2) Facilitation provided by city staff and the chair of the Blue Ribbon Panel enabled a
dynamic response to barriers and capitalized on political urgency to drive implementation of adaptation actions. (3) Adaptation actions that addressed risks at multiple timeframes – immediate, short, and long term – were more successful than those that did not. Additionally, for academic adaptation scholars, the Relational Theory of Risk is demonstrated as a useful tool for defining risks from the perspective of adaptation decision makers as they evolve over time.

3.2 Motivation and Framework

The study of climate change adaptation is a growing field that has seen a sharp increase in academic publications in the last decade (Bassett and Fogelman, 2013; Moser and Boykoff, 2013). Adger et al. (2005) define adaptation broadly as,

adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities.

Adaptation can also be defined more narrowly in terms of government actions as,

the process leading to the production of outputs in forms of activities and decisions taken by purposeful public and private actors at different administrative levels and in different sectors, which deals intentionally with climate change impacts, and whose outcomes attempt to substantially impact actor groups, sectors, or geographical areas that are vulnerable to climate change. (Dupuis and Biesbroek, 2013)

Planning has been the focus of the majority of adaptation at the national, regional, and city level (Bauer and Steurer, 2014; Bierbaum et al., 2013b; Hunt and Watkiss, 2011). Cities have been most active implementers, for example, New York City’s response to Hurricane Sandy (Rosenzweig and Solecki, 2014) and Rotterdam’s experiments with climate adaptive flood management (Uittenbroek et al., 2013). However, implementation remains a challenge for most local governments in the United
74

States (Ekstrom and Moser, 2014; Hughes, 2015) and is understudied by academics (Dovers and Hezri, 2010), contributing to a gap between climate change research and actionable knowledge (Kirchhoff et al., 2013; Lemos et al., 2012). To bridge this gap, applied research is needed that advances both the academic goal of identifying generalizable truths about adaptation and the practical needs of local government (Preston et al., 2015).

Implementing adaptation actions requires a departure from existing institutional and technological norms, driven by a combination of current impacts and anticipated future threats (Kates et al., 2012). The limited number of adaptation case studies and the fact that implementation may be underreported (Broto and Bulkeley, 2013) suggest that if governments are going to be able to learn from each other, frameworks and theories of adaptation need to be informed by practical successes and failures. For example, ‘no regrets’ solutions that address known immediate risks and do not limit future options to respond to uncertain future risks are theoretically ideal but practically difficult to translate from one context to another (Preston et al., 2015). Consequently, frameworks for analyzing case studies of implementation are needed that accurately describe adaptation mechanisms, enabling theory development through multi-case comparisons and practitioner reflection.

The diverse physical impacts of climate change and the range of governance structures responsible for climate adaptation make it challenging to describe mechanisms that are flexible yet precise enough to enable learning from mistakes and successes (Eisenack et al., 2014). Researchers need to focus their work on studying the effective if sub-optimal ‘clumsy’ solutions that emerge within government adaptation efforts (Dilling
et al., 2015). Treating climate adaptation as a socially constructed phenomenon opens up the contextual nature of adaptation actions and enables learning that can be extended across cases (Adger et al., 2009b).

3.2.1 Risk

The main task of local government is to provide services that protect its citizens and their property from hazards (Burkett, 2013). Because of this, risk management is pervasive as a paradigm in government decision making. As Western culture has embraced the concept of risk, decisions are increasingly framed in terms of risk mitigation (Beck, 1992). Miami Beach’s investment in climate adaptation is a risk management decision, the choice to reduce possible future costs of sea level rise by spending money on resilient infrastructure now (Hunt and Watkiss, 2011). Risk perception and the challenge of dealing with future threats is one of the most well documented behavioral barriers preventing a proactive response to climate change (Bazerman, 2006; Weber and Stern, 2011). For example, Rotterdam residents’ perceived risk of children drowning in a proposed watersquare, a public park combining recreation facilities and stormwater retention, became an insurmountable barrier in the city’s initial attempt to implement the climate adaptive water management project (Biesbroek et al., 2014).

Risks, future negative contingencies, can be defined broadly as any bad things that could happen in the future (Boholm, 2015). When people make decisions, the risks they choose to manage are socially and psychologically constructed (Douglas and Wildavsky, 1982; Fischhoff, 2012; Loewenstein et al., 2001). In a policy context, this means that the description of a risk defines the problem and the possible responses
(Slovic, 2000). However, nearly anything from an asteroid to a heart murmur or rising seas can be described as a risk. The lack of agreement on what exactly people mean when they talk about a risk – there are over twenty-five scholarly definitions of risk just in the study of natural hazards – makes analyzing risk management decisions at the city level difficult (Romero-Lankao et al., 2014).

![Diagram of the Relational Theory of Risk](image)

**Figure 3.1: Extension of the Relational Theory of Risk.**

Effective analysis requires a well-structured definition of risk. The Relational Theory of Risk (Boholm and Corvellec, 2011), described in Chapter 1 Section 1.3.6, provides a path forward by unifying definitions of risk across multiple fields. It has been applied to government decision making about infrastructure investments and public health, and as a framework for analyzing how water managers adopt sustainable technology (Dobbie and Brown, 2014). This is the first application of the Relational Theory of Risk specifically to climate adaptation, and to increase applicability to climate...
risks, we specify three components of the risk relationship that links threats and values: (1) a pathway specifying how the threat will harm the value, (2) timeframe of when the harm is expected to occur, and (3) an uncertainty description of how likely the harm is to occur (see Figure 3.1). This flexible yet rigorous definition of risk can be used to relate the risks that drive and impede adaptation decisions.

3.2.2 Urgency and Accelerated Change

Urgency is commonly identified as a positive force for adaptation, driven by the recognition that policy changes are needed to address coming climate threats (Preston et al., 2015). Exposure to external forces (e.g., physical, political, regulatory, financial) are theorized to drive fundamental adjustments in the governance of resources (Bijker, 2007; Geels, 2005; Hughes et al., 2013). Accelerated periods of policy change, driven by an urgency to respond to exposure to disruptive forces like flooding or drought, have been documented in the analysis of transitions towards sustainable, adaptive water management in Los Angeles (Hughes et al., 2013), Miami (Treuer et al., 2017), and the Netherlands (van Herk et al., 2015).

Sustained adaptation requires a transition, a permanent shift away from existing policy based on historic norms to an iterative process that responds to “observed or expected changes” in the climate to prevent negative impacts (Adger et al., 2005). Complex socio-technical transitions like climate adaptation and water management usually require decades of gradual change across multiple levels of society and governance (Geels, 2005). However, within these transitions there are moments of accelerated change, over months or years, in which new ideas and technologies break through (Geels and Schot, 2007), often in the form of local government experiments.
designed to address an unmet, urgent need (de Haan et al., 2015).

The Oxford English Dictionary defines urgency as “importance requiring swift action.” Urgency is the result of a perceived risk that has been amplified within a community to the point where it requires immediate action (Kasperson et al., 1988). For example, in Miami Beach regular flooding and heightened media coverage since the late 1990s (Wdowinski et al., 2016) has increased the perceived threat of sea level rise. In a political context, leaders have an urgent need to take recognizable action within a compressed timeframe, typically driven by a deadline such as re-election (Medd and Marvin, 2005). Urgency motivates short-term action and may also complicate long-term planning (Preston et al., 2015). Long-term planning represents a critical challenge for decision makers’ efforts to mitigate climate change impacts. These efforts are challenged by short-term goals and motivations of elected officials, limited strategies for funding and measuring returns from long-term investments, and the need to address more immediate policy demands within a resource constrained decision environment. However, urgency can help to overcome procrastination which causes myopic decision making around problems like climate change where impacts are perceived as distant and difficult to address (Meyer and Kunreuther, 2017). Problematizing climate change as a risk can drive “urgency to act” in vulnerable communities, creating opportunities to transition away from short-term thinking and engage in climate adaptation that protects them against long-term risks (Jhagroe and Loorbach, 2015).

Policy actions that occur as a result of urgency need to be examined to understand how they relate to long-term planning strategies and goals. Barriers like unanticipated

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23 https://en.oxforddictionaries.com/definition/urgency
technical problems often arise that divert attention and resources away from long-term planning (Measham et al., 2011). Studying periods of accelerated change within adaptation experiments provides an opportunity to extract lessons without waiting for the entire process of transition to resolve. This enables successes to be replicated rapidly and repetition of mistakes to be avoided. Studying implementation through accelerated periods of policy change provides a focal point for comparison across highly contextual experiences (Treuer, et al). Recurrent mechanisms that create barriers can then be identified, the product of actors making choices and interacting over time in a unique context (Biesbroek, 2014).

3.2.3 Barriers and transitions

Common categories of climate adaptation barriers have been identified through case study reviews (Bierbaum et al., 2013b; Biesbroek et al., 2013). The National Climate Assessment which identifies six categories of barriers (Bierbaum et al., 2013a):

1. Lack of leadership,
2. Lack of resources,
3. Available climate information,
4. Fragmented decision-making,
5. Divergent risk perceptions and values (including conflicting timescales),
6. Institutional constraints.

In complex activities, like transitioning water management policy to account for long-term climate impacts, barriers are anticipated but often appear as surprises demanding immediate attention from decision makers (Norgaard et al., 2009). Research on the dynamics of how barriers arise is needed to systematically understand their role in
implementation of adaptation actions, i.e., when they block actions and when they force innovation.

Time is a critical component of understanding the rise of adaptation barriers during periods of accelerated change. Adaptation efforts must be analyzed longitudinally because drivers and barriers of change evolve over time along with contextual factors (Eisenack et al., 2014). Unconventional approaches and compressed timelines within adaptation experiments challenge existing legal, financial, governance and political institutions (Jhagroe and Loorbach, 2015). Disrupting the status quo often requires new collaborative relationships (Corfee-Morlot et al., 2011).

Successful adaptation follows an iterative process (Moss et al., 2014), and identifying where barriers arise in the process can help predict when they will arise. Transition Management identifies a prescriptive four stage iterative process that occurs over a relatively short period of accelerated change to facilitate implementation of new sustainable adaptation policies (Figure 3.2) (Loorbach, 2010). These four stages are:

1. Problem structuring and envisioning of solutions,
2. Agenda building with coalitions around specific actions,
3. Experimentation and implementation of adaptation actions,
4. Evaluation, monitoring, learning and adjusting to stabilize change.
The Transition Management framework is particularly relevant for this study because it was developed to help government decision makers purposefully exploit moments of ‘disequilibria’ and urgency to create operational changes that tactically engage systemic complexity on multiple timescales (Loorbach, 2010). Punctuated Equilibrium Theory, a conceptual inspiration for Transition Management, describes policy change in which an abrupt departure from the past occurs, breaking the path dependency of the typically stable policy landscape (Baumgartner et al., 2014). Transition Management has been used to successfully guide climate adaptive water management in the Netherlands (Jhagroe and Loorbach, 2015) and found to be present in adaptive agriculture (Park et al., 2012) and urban water management transitions (Brown

Figure 3.2: Transition Management cycle (Loorbach, 2007)
et al., 2013) in Australia. In this chapter, we use the urgency, risk, and barriers framework described below to describe the case of accelerated adaptation in Miami Beach and to pinpoint where in the Transition Management cycle barriers arose.

3.2.4 Framework

This chapter presents a case study of adaptation decision making by public and semi-public actors within the city of Miami Beach as they intentionally took action to respond to the anticipated impacts of climate change induced sea level rise on stormwater management. It focuses on a period of accelerated policy change between 2014 and 2015. To analyze the accelerated period of change in Miami Beach’s transition to adaptation, we propose an analytical framework that connects urgency as the manifestation of forces driving change to barriers as dynamic impediments to change impediments to change, using a relational definition of risk as a heuristic to describe the perceived threat of climate change to individual and community values (see Figure 3.3). The urgency, barriers, and risk (UBR) framework enables us to follow how exposure to drivers of change are translated into specific adaptation actions over time. Mechanisms driving barriers have been proposed as a way to treat barriers dynamically and extract generalizable lessons (Biesbroek et al., 2014).

In the UBR framework (Figure 3.3), exposure to forces of change like physical impacts (e.g., flooding) and political pressure (e.g., election promises) amplify the threat of climate change (e.g., sea level rise) and create urgency to act. Before action can be taken, risks are identified that describe the potential for a climate change threat to harm something of value (e.g., a city), often on multiple timescales. The timeframe, likelihood, and pathways articulated within the risk inform adaptation actions. Actions, proposed or
taken, attract attention and lead to the construction of new risks by impacted stakeholders (e.g., citizens or government partners) that perceive the adaptation action as a threat. This leads to opposition in the form of barriers which slow down the process. Barriers further compress the urgent need to act, leading to adjustment in adaptation actions to appease or overcome barriers.

![Diagram](image)

Figure 3.3. The Urgency, Barriers, and Risk (UBR) Framework.

### 3.2.5 Methods

The UBR framework is used to integrate multiple data sources covering approximately three years of adaptation. The research reported encompasses climate adaptation efforts in Miami Beach between the election of a new mayor in 2013 and 2016, the first year after his re-election. It focuses on the key period of accelerated
change between the creation of the Mayor’s Blue Ribbon Panel on Flooding and Sea Level Rise (Blue Ribbon Panel) in January 2014 and its renewal in January 2015. Miami Beach was chosen as a subject because it is one of the first cities in South Florida and the United States to commit serious resources to climate adaptation. Aware of the city’s vulnerability and lack of action, when it became clear that the political will was present to shift policy, we took the opportunity to observe and document the policy transition as it occurred.

We rely upon multiple sources of qualitative data including semi-structured interviews, observation of public meetings, document review, and participant observation. The range of sources were selected to provide a breadth of information over time that could be used to triangulate around key issues (Eisenhardt, 1989). Over the year, activities included: 13 semi-structured interviews with city staff (5), politicians (2), contractors (1) and engaged residents including members of the panel (6); analysis of meeting minutes, agendas, and attendance for 22 Blue Ribbon Panel meetings; observation of 49 panel, committee, commission, and community meetings addressing various aspects of sea level rise; and participation in the city’s collaboration with local academics. Ongoing observation of government meetings, elections, city communication, media coverage, social media, and conversations with city staff and residents through 2016 have provided additional insights and context when analyzing data gathered during the primary study period. This deep investigation enables the identification of distinctive characteristics that make a case special (Flyvbjerg, 2006).

Data was analyzed within the urgency, barriers, and risk framework introduced above (Section 2.2) through an accumulation of methods. Using a process similar to
Rapid Ethnography, two researchers analyzed the data to achieve a broader comparative perspective (Baines and Cunningham, 2013). After the completion of primary data collection, an embedded researcher was interrogated by a fellow researcher who had reviewed the data but was relatively removed from the data collection process. This interrogation was used to inform further data analysis and develop theoretically relevant conclusions. Data collected was used to generate a timeline of the appearance of actors, adaptation actions, risks and barriers within the adaptation process, including stages of the Transition Management cycle. Individual risks were identified by first analyzing meeting minutes from the Blue Ribbon Panel using a structure based upon the definition of climate risks, derived from the Relational Theory of Risk in which a risk was deemed present in the City’s decision making process once the value, threat, and link were articulated within a meeting. These risks were then verified against field notes and interviews. Barriers, following the National Climate Assessment’s six categories (Bierbaum et al., 2013b), were identified in a similar process to risks but beginning with field notes and interviews which were then verified against meeting minutes and related public documents. The timeline, field notes, interviews, and results of comparative perspective interrogation were used to generate a narrative of transition (Figure 3.4), in which actors’ actions, risks, barriers, and events are arranged to highlight the temporal sequence of the policy transition.

3.3 Adaptation in Miami Beach

Starting in 2013, during the first 18 months of intense accelerated adaptation, Miami Beach identified three primary risks, pursued four adaptation actions, and encountered barriers to all of these actions that shaped the City’s subsequent decisions.
This section identifies risks, actions, and barriers and places them within a narrative case study of adaptation in Miami Beach, highlighting the efforts of the Mayor’s Blue Ribbon Panel on Flooding and Sea Level Rise. This narrative is divided into four stages: Forces driving urgency (3.3.2.1), Problem identification and agenda setting (3.3.2.2), Experimentation, implementation and the emergence of barriers (3.3.2.3), Evaluation and stabilization (3.3.2.4).

3.3.1 **Risks, Actions, and Barriers**

Over the first six months of 2014, the Blue Ribbon Panel coalesced around three increasingly immediate risks. First, a long-term risk that multiple feet of sea level rise was likely to make much of Miami Beach uninhabitable by 2100 and maybe as early as 2060 unless changes were made to water management and development. Second, short-term risk that negative press and repeated flooding could cause real estate investors to abandon Miami Beach, collapsing the tax base and making investments in the future impossible, unless a credible solution was implemented to control flooding. A third, more immediate risk was identified after the first two: Unless visible solutions were implemented before 2015, the mayor was unlikely to be re-elected, and neither short-term nor long-term risks would be addressed.

Multiple solutions were proposed by city staff and members of the Blue Ribbon Panel, and four actions were pursued within the first year:

1. The adoption of increased minimum height and more robust construction standards for seawalls.
2. The development of a plan to protect the storm sewer system from tidal flooding with new stormwater pumps, larger pipes, and outflow valves.
(3) Redesign of the proposed Collins Park Garage to three feet above the 100-year floodplain as an adaptation demonstration project.

(4) Raising of roads to a minimum elevation of 1.1 m (3.7 ft) NAVD as new stormwater pumps and sewers were installed in the lowest areas of the city (sites of regular flooding), beginning with Sunset Harbour.

As stakeholders became aware of these actions, barriers arose in response. Residential building contractors working in the city opposed seawall standards, arguing that it would require yards to be raised, which would create unappealing discontinuity with neighboring properties. Environmentalists raised concerns about pumps polluting Biscayne Bay and city canals with unfiltered runoff from streets. Miami-Dade County was unwilling to work with the city to elevate the road and sidewalk around the proposed Collins Park Garage. Residents and business owners in flood prone neighborhoods worried about increased flooding if streets were elevated above their sidewalks, doorways, and garages. Additionally, historical preservationists and city planners worried about disruption of the historical nature and walkability of neighborhoods.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long-term catastrophic sea level rise</strong> – Multiple feet of sea level rise are very likely to make Miami Beach uninhabitable by 2100 and as early as 2060 unless major changes are made.</td>
<td><strong>Long-term</strong> (30+ years)</td>
</tr>
<tr>
<td><strong>Short-term loss of confidence</strong> – Investors could abandon Miami Beach, collapsing the tax base and making investments in the future impossible, unless a credible solution is implemented to control flooding.</td>
<td><strong>Short-term</strong> (&gt;10 years)</td>
</tr>
<tr>
<td><strong>Mayoral re-election</strong> – Unless visible solutions are implemented before 2015, the mayor is unlikely to be re-elected, and neither short-term nor long-term risks will be addressed.</td>
<td><strong>Immediate</strong> (&gt;2 years)</td>
</tr>
</tbody>
</table>
### Adaptation Actions

<table>
<thead>
<tr>
<th>Action</th>
<th>Timeframe</th>
</tr>
</thead>
</table>
| **Seawalls** – Increased minimum height and more robust construction standards for public and private seawalls. | Short-term  
|                         | Long-term          |
| **Stormwater pumps** – Install over 60 new stormwater pumps along with backflow valves on outfalls to disconnect the storm sewers from tidal flooding. | Immediate  
|                         | Short-term          |
| **Collins Park Garage** – Build a new mixed use garage three feet higher as a public demonstration project for how buildings can be elevated against future sea level rise. | Long-term |
| **Elevate roads** – Raise roads to a minimum elevation of 1.1 m (3.7 ft) NAVD as new stormwater pumps and sewers are installed, beginning in the lowest areas of the city that flood regularly. | Immediate  
|                         | Short-term  
|                         | Long-term          |

Table 3.1: Risks identified and adaptation actions pursued by the Blue Ribbon Panel in 2014.

### Barrier

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Barrier type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contractors</strong> – Contractor opposition to seawall standard because it required yards to be raised which would create unappealing discontinuity with neighboring properties.</td>
<td>Institutional constraints &amp; Divergent risk perceptions</td>
</tr>
<tr>
<td><strong>Environmental</strong> – Opposition to pumps because they are polluting Biscayne Bay and city canals with dirty water.</td>
<td>Divergent risk perceptions</td>
</tr>
<tr>
<td><strong>County</strong> – Miami-Dade County’s unwillingness to cooperate on Collins Park Garage.</td>
<td>Institutional constraints &amp; Fragmented decision making</td>
</tr>
<tr>
<td><strong>NIMBY</strong> – Resident “not in my backyard” concerns from neighbors about elevated roads causing new flooding or damaging the historical feel of the neighborhood.</td>
<td>Divergent risk perceptions</td>
</tr>
</tbody>
</table>

Table 3.2: Barriers to initial adaptation actions pursued by Miami Beach.
3.3.2 The Case of Miami Beach

3.3.2.1 Forces Driving Urgency

In 1997, Miami Beach created its first stormwater master plan to deal with flooding from rainstorms. In the early 2000s, the city began to experience an increase in seasonal flooding related to high tides and rising sea levels (Wdowinski et al., 2016). In response, Miami Beach adopted a new stormwater master plan in 2012. This plan, like the original, relied primarily on gravity to remove rainwater and was only designed to accommodate 0.15 m (0.5 ft) of sea level rise – despite mayoral and City Commission acknowledgement of projections at the time of 0.2-0.6 m (0.75-2 ft) of sea level rise by 2060, provided by a respected panel of experts convened by the Southeast Florida Climate Change Compact. If seas rise 0.4 m (1.3 ft) by 2050, the Miami region could face $25 billion in annual losses unless significant changes are made in development patterns and flood protection (Hallegette et al., 2013a). To counter this threat, local governments banded together to create the Southeast Florida Climate Change Compact in 2009 which helps coordinate the regional response to climate change by providing knowledge sharing and planning support (Vella et al., 2016).

In the fall of 2012, King Tides flooded Sunset Harbour, West Avenue, and other areas of Miami Beach. The city was criticized for its inadequate stormwater plan by residents at public meetings and again in June 2013 in a *Rolling Stone* article, highlighting the threat of sea level rise (Goodell, 2013). In November 2013, a new Mayor and Commission were elected on a promise to deal with flooding and prepare for sea level rise (Veiga, 2013). In Miami Beach, mayors are elected to two-year terms and commissioners to four-year terms. This created a heightened sense of urgency for the
incoming administration. Fortunately for the mayor, a new city manager had recently been hired along with other key staff, including a public works director, were eager to address flooding and sea level rise. Just after the election, a new city engineer was hired who moved from California, because he was promised that he would be given the financial and political support to remake the stormwater system in Miami Beach (interview, November 17, 2014).

3.3.2.2 Problem Identification and Agenda Setting

In January 2014, the mayor created the Mayor’s Blue Ribbon Panel on Flooding and Sea Level Rise (the Panel) with “the purpose of overseeing the City's response to flooding, including stormwater and the effects of sea level rise, and assisting with the implementation of a comprehensive flood management plan for the City of Miami Beach.” The chair, a local developer, business partner of the mayor, and lifelong resident, was assisted by two retired engineers who had been vocal opponents of the 2012 stormwater master plan. Beginning in late January, the Blue Ribbon Panel held bi-weekly meetings at city hall with city staff for the next year. These meetings were held in a conference room, open to the public.

Regular attendees included commissioners sitting on the City Commission’s Flooding Committee, the public works director, the city engineer, environmental staff—added after recognition of permitting challenges—the capital improvements director, and a concerned citizen who had been part of the County’s previous climate change planning. Attendance by other staff, outside experts, contractors, residents, academics, and media fluctuated throughout the year (see figure 3.5).

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24 January 6, 2014 memo from the Mayor creating the Blue Ribbon Panel.
Initially, many solutions were considered. At the first meeting, staff suggested installing more stormwater pumps, raising seawall standards – because the city has sole jurisdiction over seawalls, and redesigning the proposed Collins Park Garage – a parking facility and retail space designed by star architect Zaha Hadid – at a higher elevation. In subsequent meetings the Panel heard proposals to build a 200-foot subterranean wall around the city, remove stormwater with deep water injection wells, and convert streets to canals. In February, as it began to assess the problem, the Panel first identified the long-term risk of multiple feet of sea level rise submerging large parts of the city. By March, it identified a more urgent short-term risk, within a decade, of flooding leading to a collapse of confidence in the local real estate market.

Through these first months, ongoing neighborhood improvement projects in low lying areas, primarily led by the Capital Improvement Projects team, were modified to include new pumps or were stalled to avoid constructing vulnerable infrastructure. The installation of new pumps raised permitting issues, and the two-woman environmental team was asked to join the Panel’s meetings in March. This addition facilitated new collaborations internally – the environmental team was housed within the city manager’s office and interacted regularly with the public works, planning, building, parks, transportation, and communication departments – and regionally through the environmental teams ongoing participation in the Southeast Florida Climate Change Compact.

By early summer a third more immediate risk was identified within Blue Ribbon Panel meetings. If a plan was not in place and action was not underway by King Tide in October 2014, it would be unlikely the mayor would be re-elected in 2015 and neither the
short or long-term risks could be addressed. Articulation of this risk by the Panel chair solidified the sense of urgency among city staff and led to the recognition that messaging needed to be a priority. City employees and leaders began to work on “the story,” a messaging campaign about the city’s response, ultimately labeled “Miami Beach Rising Above.” The immediate goal was to have a successful King Tide Day in October 2014, in which the city kept the streets dry and proved its program was working.

The Panel and city staff worked with the city commission and mayor to establish a plan for action that would result in a successful King Tide Day. The mayor often mentioned a need to avoid ‘analysis paralysis’, and the new city engineer was empowered to push rapid adoption of new standards so implementation could begin. In response to challenges with environmental permitting, a state of emergency was issued enabling the city to bypass some regulations. Finance challenges were anticipated, and a resolution was sent to the commission to spend $200 million on accelerated stormwater management. A plan for raising stormwater fees was introduced in early summer to provide $100 million in funds and is passed in October 2014. Additional funding came from the Capital Improvements Project fund, created after 1997 to implement the city’s initial stormwater master plan, and the South of Fifth Redevelopment Authority which was running a multi-million dollar annual surplus.

As the number of projects increased and typical staff turnover occurred, concerns were raised about stretching city staff too thin and maintaining expertise. At the urging of the panel chair, AECOM was hired as an outside consulting firm to create a stormwater model of the city, provide “peer review” for city staff, and to help with future updates to city code. Academics from universities were also brought in to collaborate with the city;
unfortunately, the academics’ focus on raising awareness about future flooding by highlighting past events conflicted with the City’s message that flooding had been reduced through the installation of pumps and valves.

### 3.3.2.3 Experimentation, Implementation, and the Emergence of Barriers

The first adaptation actions and significant barriers occurred over the summer. Initially proposed in January, in June the city’s Collins Park garage is redesigned to increase its base floor elevation to 0.9 m (3 ft). A minimum standard for road heights and critical infrastructure of 1.1 m (3.7 ft) NAVD 88 (a datum, the starting point for measurement of elevation) was championed by Public Works and the city engineer. This required the city to raise the streets around the proposed garage to the new minimum of 1.1 m (3.7 ft). However, the street and half the sidewalk were owned by Miami-Dade County. The head of the panel met with city and county staff, and despite multiple redesigns the county refused to comply with city requests to raise the street, not wishing to set the precedent of raising public streets. The project was stalled and eventually abandoned in the spring of 2015 after a new ‘knee wall’ design that would allow the first floor to be filled as the streets around it were raised was found to be too expensive (see Figure 3.6).

A new seawall standard, also first proposed in the initial January 2014 meeting, was passed by the city commission in July, raising the minimum height from 3.2’ NAVD to 5.7’. Months later, in December 2014, the seawall standards received significant pushback from private contractors working in the city claiming it was much more than a 2.5’ increase because of confusion about the NAVD/NGVD. “We don’t want to have to do math,” one contractor told the City Commission. In a compromise, the new height
standard was suspended for a year. However in 2016, after the successful re-election of the mayor the 5.7’ height originally proposed by the city engineer was reinstated.

In the summer of 2014 as the first of over 60 new pumps were being purchased, questions were raised by Panel members about the long-term viability of pumping sea water out of the city. Pumps would need to be replaced in approximately 15 years, and would be running constantly with over a foot of sea level rise creating extra economic and environmental costs. At the same time city planners and historical preservationists raised questions about the viability of elevating buildings multiple feet above the road. They would tower over existing buildings and create an unpleasant pedestrian experience. These challenges led to a new goal proposed by the city engineer in October 2014: raising the crown of the road on all streets in the city to a minimum of 1.1 m (3.7 ft) NAVD, with pump systems installed underneath to remove stormwater and prevent flooding in buildings that would be lower than street level. A long-term vision was articulated that, in a city which is 95% urbanized and rapidly redeveloping, these low buildings would eventually be rebuilt at a higher elevation and historic structures could possibly be elevated.

When King Tide day arrived on October 9, 2014 it was a success for the city and the Panel. Two senators and the head of the EPA gave speeches covered by national and local news media. Newly installed valves on stormwater outfall pipes and temporary pumps prevented most visible flooding. The primary fear was rain, because without new large pumps in place there was no way to get water out of the now dry city. Luckily for Miami Beach it was sunny and dry. A few weeks later, at the State of City address the mayor lauded the efforts of city staff and declared that he wanted Miami Beach to be the
“best city in the world.”

The raising of streets was accepted by the City Commission as a necessary action for low parts of the city, especially those where new pumps and stormwater pipes were to be installed. However, plans to raise the streets and the quick pace of implementation led to public concern in December 2014. Hundreds of residents attended meetings with Sunset Harbour and West Avenue neighborhood groups in January 2015. In these meetings city staff described the plan and told the story established by the city communications team. Pushback from residents included questions about water from streets flooding buildings, loss of parking, and how furniture deliveries would be made in the future. In response, the chair of the Blue Ribbon Panel demonstrated his third-party status, stating that he was not part of the city and not getting paid. The residents of Sunset Harbour and West Avenue could either accept the improvements and participate in the process or the city would spend $20 million in another neighborhood. The city engineer also offered to meet with any homeowner or business owner who had concerns and show them how the city would protect their property.

3.3.2.4 Evaluation and Stabilization

Participants in the Blue Ribbon Panel played key roles in responding to challenges and maintaining progress. Throughout the first year, environmental staff played an important role facilitating intra-department collaboration. They also brought in information from the regional network of resilience and sustainability staff working in neighboring cities and counties, helped address permitting challenges with regulators, and participated in communication efforts. They played a key role in developing the Miami Beach Rising Above story by attending conferences, providing public tours and
comments for the media and public, and working with staff to generate educational materials, including street signs, handouts, and websites.\footnote{26 http://miamibeachfl.gov/risingabove/}

In interviews and conversations, contractors who worked on stormwater installations, street construction, and permitting reported that the pace of work in fall 2014 and winter 2015 was by far the fastest they had experienced in South Florida. Contractors, city staff, and politicians all gave credit to the city engineer’s clear communication, open attitude, and aggressive timelines for the accelerated pace. Seen to have the full support of the Public Works Department and the administration, he was constantly available to discuss projects.

In January 2015, the Blue Ribbon Panel was renewed for a second year. The Panel chair helped lead a city effort to lobby the state for funding, flying up to Tallahassee with politicians and staff. City work focused on installation of pumps and raising streets in the Sunset Harbor neighborhood – beginning in March 2015 and continuing into 2017. Implementation continued on the initial phase of the plan leading up to the Mayor’s re-election in November 2015, right after King Tide – a major test for his signature initiative. With new pumps and higher streets in the most vulnerable areas, disruptive flooding in 2015 was concentrated on Indian Creek Boulevard, a state owned road. The major thoroughfare was impassable for multiple hours each day in the week of King Tide. The Panel chair, mayor, city engineer, and others flew to the state capitol to lobby the governor for support. Ultimately, this resulted in the state committing $20 million to improve and begin raising Indian Creek in 2017.
New, large pumps along West Avenue led to increased turbidity and concentrated presence of pollutants from the streets in city canals and Biscayne Bay. Environmental risks became a contentious issue in the 2015 mayoral re-election and eventually led to confrontations at Commission meetings between elected officials and local scientists. When the *Miami Herald* reported on the confrontation and resident concerns, it was considered an unfair critique because the data reflected increases in intensity not overall pollution. In retrospect, this was identified as one of the biggest barriers to action by the chair of the Blue Ribbon Panel. Addressing these concerns remains an ongoing challenge in Miami Beach, though new underground containers designed to separate out pollutants before water is pumped into waterways have been added to future projects.

To address the increasingly complex task of managing sea level rise adaptation, the city hired a chief resilience officer as a deputy city manager in September 2015. According to the chair, this took pressure off the Blue Ribbon Panel and expanded the scope of adaptation. He reported that the new hire will be extremely important for future success as the initial urgency passes.

Following a slight pause in activity leading up to the re-election of the mayor and many of his allies on the city commission in November 2015, implementation of plans continued at a quick pace in 2016. Additionally new building code and elevation standards have been proposed or adopted, including measuring maximum elevation from a building’s floor elevation rather than the road and a new building fee structure designed to encourage adoption of green building standards. In the summer of 2016, Miami Beach was accepted as part of the Rockefeller Foundation 100 Resilient Cities initiative in partnership with the City of Miami and Miami-Dade County. This signaled a new spirit
of coordination between the cities and the county. Disputes about jurisdiction, timeframes, and who will pay for improvements like raising streets and installing pumps continued, but the venue has now shifted out of the Blue Ribbon Panel and into the professional offices of city and county staff.

3.4 Discussion and Recommendations

In this section, the UBR framework is used to analyze the City’s response to sea level rise. Three lessons are extracted from the case of Miami Beach and two recommendations are made for practitioners of climate adaptation. Finally, avenues for future research are proposed.

3.4.1 Discussion

Seen through the lens of urgency and barriers, the Miami Beach’s adaptation effort follows a pattern of action and response. Urgent pressure to act drove political leaders to initiate a period of problem assessment in January 2014, guided by the Mayor’s Blue Ribbon Panel. Mayoral and staff focus on finding and implementing solutions meant that some of the initial ideas proposed, such as the Collins Park Garage project, did not actually address most of the risks that were later identified. The focus on solutions also created opportunities to experiment and helped to maintain momentum as barriers arose.

Over the first five months, three interconnected, increasingly immediate risks were identified and matched to proposed solutions. As stakeholders, e.g., the County, became aware of proposed solutions, e.g., elevating the Collins Park Garage, they were framed as disruptive risks to the status quo, e.g., pushing the County to set a precedent on sea level response. This slowed the process without removing any of the urgent need to
Act. Repeatedly the City framed barriers as a threat to the immediate need to act, leading to new or adjusted solutions. In this way, raising streets, seen initially as unfeasible for political reasons, became favored. Sunset Harbour, where pumps were already being installed, could be a demonstration project with multiple co-benefits. It visibly addressed immediate and short-term risks directly, and provided an argument for how the city could be transformed to address the long-term risk of multi-foot sea level rise. Opposition to raising streets from residents was overcome through engagement and an appeal to urgency by the Panel chair. Investment was going to happen, why not do it in your neighborhood when the streets are already ripped up to install the new drainage system?

Miami Beach is now working to raise streets and install pumps in other neighborhoods as it updates its building code to encourage adaptive construction from the private sector. Leadership is changing. The mayor is retiring, and as a Blue Ribbon Panel member said, “I am more worried than I was when I started. But now it is time to let someone else take the lead” (interview, February 21, 2017).

Local governments in South Florida are attempting to duplicate the success in Miami Beach. For example Miami-Dade County and the City of Miami have both hired chief resilience officers and with Miami Beach are working on resilience with the support of the Rockefeller Foundation’s 100 Resilient Cities program. Miami and Miami-Dade are responsible for much larger populations and geographic areas than Miami Beach. Governance is less concentrated, and the process of adaptation is moving slowly. Sea level rise solutions will look different and require navigating a more complicated governance structure. Additionally, despite a relative increase in recognition of the problem of sea level rise amongst elected officials in both Miami and Miami-Dade
County, they lack the sense of urgency present in Miami Beach (Miami-Dade County
Mayor’s Facebook Townhall August 11, 2016, City of Miami Sea Level Rise Committee
meeting March 14, 2016). Mayors in cities including Coral Gables, and South Miami are
actively working to increase recognition of the threat to their communities from climate
change, especially sea level rise. However, none of these cities have made investments in
adaptation comparable to Miami Beach (Southeast Florida Climate Change Compact,
2017).

Strong leadership and financial support for adaptation meant that in Miami Beach
implementation barriers were primarily driven by institutional constraints and stakeholder
risk perceptions. One positive, potentially unacknowledged aspect of these particular
barriers is that they functioned as entry points into the adaptation process for previously
disengaged stakeholders. Early opponents to city action, including Miami-Dade County,
the Florida Department of Transportation, and neighborhood associations have become
partners in adaptation.

Urgency drove Miami Beach’s adaptation efforts during the first 18 months of
accelerated change but waned after the mayor’s re-election as adaptation became
normalized and integrated into routine activities. However, every fall King Tides and the
threat of hurricanes provide new urgency to complete actions as well as an opportunity to
reflect on changes that have been made over the past year. To maintain support from
residents and stakeholders, framing the city’s adaptation investments in terms of evolving
immediate, short, and long term benefits remains important.
3.4.2 Findings and Future Research

Analyzing the dynamic relationship between urgency, barriers, and adaptation actions in Miami Beach over time highlights three conclusions. (1) Barriers appeared towards the end of the agenda setting phase and early in implementation, when newly engaged stakeholders recognized and opposed specific adaptation actions. (2) Facilitation provided by city staff and the chair of the Blue Ribbon Panel enabled an active response to barriers. They were able to capitalize on political urgency and drive implementation of adaptation actions. (3) Adaptation actions, e.g., elevating streets, that address the risk of sea level rise at multiple timeframes – immediate, short-, and long term – were more successful in Miami Beach.

Particularly at the beginning of the adaptation process, the Blue Ribbon Panel fulfilled the role of ‘policy entrepreneurs’ – public employees who build coalitions and advocated for risk taking and experimentation in traditionally slow moving public institutions (Bartlett and Dibben, 2002). In studies of water management around the world, they helped to identify and take advantage of windows of opportunity (Meijerink and Huitema, 2010). In Miami Beach entrepreneurial staff and Panel members used three interconnected risks at different timescales to frame the problem of sea level rise, anticipated financial and political barriers, and maintained momentum by responding to unanticipated barriers. Further research is needed to understand how the skills employed in Miami Beach can be replicated in neighboring communities. This could begin with an in-depth study of chief resilience officers, hired within the past two years by the City of Miami, Miami Beach, and Miami-Dade County, paired with a survey of the knowledge sharing network developed around the Southeast Florida Climate Change Compact.
Comparisons with Dutch water sector policy entrepreneurs, recently surveyed by Brouwer and Huitema (2017), and private sector facilitators, explored in Chapter 4.

The UBR framework could be used retrospectively to compare past adaptation case studies, because existing cases of successful implementation are limited. Cross city comparisons of adaptation implementation have cataloged specific measures (Broto and Bulkeley, 2013), analyzed the effectiveness of mainstreaming climate change into decision making (Uittenbroek et al., 2013), and looked at the responsibility of public and private actors (Mees, 2016). Future comparisons could be used to test whether barriers like lack of leadership, resources, or climate information also emerge in response to the articulation of new risks by stakeholders, as the institutional barriers did in Miami Beach.

Risk perception and risk management is known to be a factor in motivating action, see for example Fischhoff (1995). We have demonstrated in Miami Beach that agreement upon a set of specific risks appeared to play an important translational role between outside forces and the urgency needed to create action. It is possible that disagreement around the definition of risks could impede adaptation efforts. New case studies, using the Relational Theory of Risk within the UBR framework, could be prospectively designed to answer the question, is consensus about risks among key decision makers a precondition for successful implementation?

Researchers could also test the relationship between risk and urgency through interventions in stakeholder processes. Urgency in Miami Beach shaped the relative importance of risks in decision making, highlighting more immediate risks and driving solutions that addressed immediate flooding problems. Proactively framing risks to highlight the urgent need to act can motivate action (Hardisty et al., 2012), but does it
limit the actions that are supported? Or does it cause conflict by highlighting disagreements between stakeholder and decision makers about relevant timeframes for action?

UBR and the Relational Theory of Risk could also be used to help add social justice issues into the adaptation agenda. Institutionalized inequality increases community vulnerability which is systematically undervalued (Adger et al., 2009a) and is under researched (Hughes, 2015) in studies of climate change adaptation, including Florida where geography, development patterns, and cultural diversity create unique challenges (Collins et al., 2017). It is possible that the reason social justice is not considered is because it is not identified within the risks associated with urgency to adapt and only comes into the adaptation conversation as a response to initial planning action. This would make integration or mainstreaming of justice issues into climate action more difficult. Researchers working co-creatively with practitioners, facilitators, and community stakeholders could intervene to integrate climate justice risks with other risks, e.g., neighborhood flooding, to influence the solutions that are perceived as viable. In Miami Beach, stakeholder elevation of environmental and temporal risks shaped the solutions that were implemented, ultimately increasing investment in co-beneficial measures that help temporarily store and clean polluted street runoff. The UBR framework provides a mechanism that describes how government and stakeholder participants can inject issues like climate justice into adaptation decisions by including it in the risk relationship pathway that connects climate threats to community values.
3.4.3 Recommendations

The experience of Miami Beach suggests two recommendations for communities that recognize their risk and the urgent need to adapt to climate change. First, facilitate a process that can navigate the disruption of institutional and community norms. A good facilitator, like the Blue Ribbon Panel in Miami Beach, will have the political savvy and technical skills necessary to guide the response by engaging stakeholders and assisting government staff to identify problems, propose solutions, and implement whatever decisions community leaders decide upon. This build the legitimacy and trust necessary to maintain adaptation (Adger et al., 2005). It can also help a community avoid protracted arguments. Both are important in a process that does not have a clear endpoint or an easily predetermined solution (Dilling, 2015). Cities should give facilitators a mandate to work with staff and stakeholders in partnership with political leaders to find solutions within an explicit period of time, linking immediate action to future benefits. The process is likely to follow a predictable pattern of problem identification, proposed solutions, experimentation, and adjustment as new stakeholders enter and respond (Loorbach and Rotmans, 2010; Mees, 2016; National Research Council, 2010).

Second, pursue solutions or adaptation actions that address climate change risks at multiple timeframes, e.g., short and long-term, and can be physically observed by residents – allowing them to see where their money is going. In Miami Beach, it was important that residents were able to talk about and express pride in their community’s efforts. These actions built confidence and created a story that helped maintain the political will to continue an evolving process of experimentation. In adaptation, the new normal is ongoing adjustment punctuated by periods of accelerated change (Park et al.,
2012). Additionally, to maintain public support and public optimism as sea levels rise, having a physical reference point helps people understand the changes in the landscape and culture required to adapt (Ingold, 2000).

The urgency that drives implementation is a valuable resource with a limited shelf life. The opportunity to transition away from business as usual towards adaptation can be maximized when local governments recognize the relationship between the risks they articulate, the risks community members perceive, and the inevitability of adaptation barriers. By pursuing strategic facilitation and observable actions that address risk at multiple timeframes, communities will be better able to attract adaptation partners and to maintain momentum by responding to barriers that often arise just as decisions have been made and implementation is about to begin.
Figure 3.4. Timeline of the Miami Beach adaptation transition.
Figure 3.5. Attendance at the first year of Blue Ribbon Panel meetings. ‘Panel’ includes members of the panel. ‘City’ includes city employees, contractors and commissioners. ‘Outside’ includes residents, academics, media, and outside experts.

Figure 3.6: Proposed redesign of Collins Park Garage. This compromise design accommodates the demands of the county by including a “knee wall” that extends flood protection to 3’ above base flood elevation and allows the main floor to be filled in the future when streets are raised. Image courtesy of the City of Miami Beach.
Figure 3.7: Cross section of street elevation and construction in Sunset Harbour. Image courtesy of the City of Miami Beach.
Chapter 4:

The Neo-Oliemannetje

Professional Policy Entrepreneurs in Adaptive Dutch Water Management
4.1 Perspective

Climate change will expose the Netherlands and coastal delta communities around the world to increased flooding, water supply, and governance challenges (Vink et al., 2013). The concept of ‘living with water’ to reduce climate risk by integrating flood management with landscape design and water supply planning was mainstreamed in the Netherlands beginning in 2007 with the €2.2 billion Room for the River infrastructure program (Rijke et al., 2012) and a €50 million Knowledge for Climate research program27 (Programme office Knowledge for Climate, 2014). However, impacts and solutions cross jurisdictional boundaries, complicating policy transitions (van Herk et al., 2015), and examples of successful implementation around the world remain mainly within local jurisdictions (Mees, 2016). This chapter argues that Dutch water managers have created a culturally specific role to help facilitate the transition towards adaptation.

To successfully adapt to climate change “a transparent, flexible, learning-by-doing approach…may be the only practical way” (Dilling, 2015). Expanding the decision process to include vulnerable populations and impacted communities may help. Participation increases legitimacy and can help reduce opposition to experimental projects, but opening up stakeholder participation can slow the process and create new management challenges (Edelenbos et al., 2011; Gottschick, 2015; Roth et al., 2017). Slow change is an unappealing prospect for communities that feel an urgent need, often driven by temporary political forces, to navigate an unfamiliar process as quickly as

27 http://www.knowledgeforclimate.nl/
possible. The challenge of implementation is heightened by the fact that existing adaptation resources are generic, primarily focused on early stage planning (Nordgren et al., 2016). This has created a need for expert facilitators that can help address the technical, jurisdictional, political, and stakeholder challenges of implementation within a project’s particular context (Nordgren et al., 2016).

Individual actors play an important role in catalyzing socio-technical transitions, including the transition to climate adaptive water management. This is true in the Netherlands (Brouwer and Biermann, 2011). It is true in South Florida (Bolson and Broad, 2013; Vella et al., 2016). And it is true in countries around the world, where policy entrepreneurs have been documented pushing conservative bureaucracies, such as water boards in the Netherlands, to take risks on innovative policy measures (Meijerink and Huitema, 2010). How they do this is an area of active study, and an important goal of that research is overcoming governance and cultural differences to extract lessons that can be transferred from one region or nation to another (Dewulf et al., 2015).

The Netherlands has experienced a transition towards integrated, climate adaptive water management since the 1990s (van der Brugge et al., 2005). It has experimented with participatory water management and devolution of decision making from the national to regional and local government, increasing the complexity of an already complex process (Brouwer, 2015; van der Brugge et al., 2005). Increased participation in water projects over the past two decades, resulting in successful innovations like the Overdeipse Polder, where farmers’ homes were raised on mounds so that their fields could periodically flood (Edelenbos et al., 2017; Roth et al., 2017). Collaboration between government agencies and academics in the Netherlands has led to experimental
management processes designed to support local adaptation policy transitions (Loorbach et al., 2015). It has also generated new skills within a community of water policy entrepreneurs, stakeholders that promote risk taking to accelerate policy change (Brouwer and Biermann, 2011; Brouwer and Huitema, 2017). These skills are a form of cultural technology, a product of the transition as valuable as the concept of “living with water”.

Academic research into participatory processes in the Netherlands are primarily funded by the Dutch government and conducted by Dutch researchers, capable of analyzing local Dutch language negotiations. This has left a cultural blind spot that makes translation of lessons to other countries difficult.

This chapter identifies an overlooked role that has emerged during the recent transition in Dutch water management, the *neo-oliemannetje* (nee-o o-lee-man-it-che): an expert who uses technical and political knowledge to catalyze policy change by working within and around existing hierarchies to promote risk taking and consensus decisions. Neo-oliemannetjes are a professional subset of Dutch policy entrepreneurs hired by governments or stakeholder groups to design and facilitate participatory water management processes. As third-party participants, they guide and legitimize stakeholder processes to accelerate policy change and adaptively implement integrated water management solutions that are efficient, effective, and equitable – a common measures of successful climate adaptation (Adger et al., 2005). The approach and skills used by the neo-oliemannetje are potentially applicable in other participatory governance systems, including in South Florida. If applied in other countries, the neo-oliemannetje could help bridge the gap between existing resources and the reported need local governments have
for help coordinating increasingly complex relationships as they work to implement climate adaptive water management projects.

Following a description of the potential for Dutch and American water management exchange (4.1.1), section 4.2 provides a historical overview of water management in the Netherlands and the recent transition towards participatory water governance in which the neo-oliemannetje developed. Next, section 4.3 introduces the neo-oliemannetje as a concept and illustrates it with three examples in section 4.4. Then, section 4.5 establishes a set of principles to support the functional replication of neo-oliemannetjes in other countries, including the United States. Finally, section 4.6 discusses opportunities for future research and practical considerations for replication by governments and individuals beyond the Dutch water sector.

4.1.1 Dutch and American Exchange

Innovative water management projects, and associated academic research, in the Netherlands is not cheap. The Dutch government spends over €700 per household per year on water management. To capitalize on this investment, the Dutch government is promoting its water management expertise through initiatives like the Delta Coalition, an international partnership of governments created to get things done to increase the resilience of urban deltas,\(^{28}\) the appointment of Henk Ovink, a water expert who led the Rebuild by Design\(^{29}\) project in New York and New Jersey after Hurricane Sandy with the United States Department of Housing and Urban Development, as Special Envoy for...

\(^{28}\) [http://www.deltacoalition.net/]

\(^{29}\) [http://www.rebuildbydesign.org/]
International Water Affairs,\textsuperscript{30} and Dutch Dialogues. These knowledge sharing initiatives, are limited by the cultural norms of the Netherlands’ top-down governance system and a perception that engineering expertise and associated decision structures are easier to export than culturally embedded planning processes (Wesselink et al., 2015; Zegwaard et al., 2015).

This cultural limitation was apparent during the Dutch Dialogues hosted by Miami Beach on September 18, 2013. Experts from the Netherlands and United States spent the day sharing innovative approaches to climate adaptive water engineering and design in city hall.\textsuperscript{31} Towards the end of the session, Miami Beach’s city planner asked the Dutch presenter, “What if we cannot get the state and county on board with our plans?” The expert on collaborative planning replied that adaptation requires a joint solution, so Miami Beach must force participate or it will not survive. He concluded that Miami Beach’s solution “will not be a Dutch solution but we are happy to help.” This answer provided a goal but no guidance on how to compel Florida’s governor, who refuses to talk about climate change, to collaborate with Miami Beach.

The United States and the Netherlands share a history of water management driven by response to crises (Bijker, 2007) and collaborate on flood management regularly, as they did after Hurricane Katrina (Kolen et al., 2012). However, Dutch engineers and social scientists often consider their culture exceptional and peculiar. In this case, the visiting Dutch expert shared a particularly Dutch consensus based approach

\textsuperscript{30} As a thematic ambassador Ovink is a booster for “the international market position of Dutch know-how and expertise.” https://www.government.nl/latest/news/2015/03/12/henk-ovink-appointed-as-first-special-envoy-for-international-water-affairs-for-the-kingdom-of-the-netherlands

\textsuperscript{31} The program and videos of the event are available on the City of Miami Beach website at http://www.miamibeachfl.gov/green/default.aspx?id=76962
to achieving successful adaptation. In stating there is no “Dutch solution” for Miami Beach, he overlooked the role of third-party facilitators in achieving consensus in Dutch water management negotiations. As described in Chapter 3, the Mayor’s Blue Ribbon Panel on Flooding and Sea Level Rise in Miami Beach provided a form of leadership that was quasi-independent from politicians and staff. Under its guidance, the city transitioned towards adaptation rapidly between the Dutch Dialogues in 2013 when the city planner was unsure about how to proceed without state or county support to the fall of 2014, when Miami Beach hosted senators and the head of the EPA at the kick-off of its $500 million investment in a sea level rise adaptive stormwater management system. The Blue Ribbon Panel was chaired by a volunteer, a local developer and longtime friend of the mayor, who described the chair in October 2016 as “his pumpman” leading the city’s response to sea level rise.

4.2 Dutch Water Management

The Netherlands is built on a river delta in northern Europe. Over 60% of the country is at or below sea level. This is a result of centuries of increasingly complex intervention in the landscape to drain and redirect the flow of water (Rijkswaterstaat, 2011). In the middle ages, farmers living on the Delta began to drain coastal marshland for agriculture using canals and small dykes. Dry peat oxidized and collapsed, sinking the land below sea level. To keep fields from flooding, windmills were used to lift water over dykes into drainage canals and rivers. Heavy rainfall or storm surges would periodically break through dykes causing death and damage, and in the 13th century landowners began to form associations called waterschappen or water boards to protect larger areas, called polders, by building networks of dykes and canals (Rijkswaterstaat, 2011). These water
boards were the first forms of democratic governance in the Netherlands and the process of negotiation developed to manage water is embedded in Dutch culture, see section 2.2 below (Brouwer, 2015).

Response to flooding events and technological advances have played a key role in the evolution of Dutch water management. Many of the first polders were built by draining shallow inland lakes or encircling coastal land with dyke rings. In the early 1800s this accelerated with the introduction of steam engines and the creation of a national “Agency for Public Works and Water Management” – now called the Rijkswaterstaat (Rijkswaterstaat, 2011). The creation of new polders in the Zuiderzee, a shallow bay near Amsterdam, were first proposed in the 1600s but were only built after a catastrophic floods in 1916 led to the creation of the Afsluitdijk, which separated the bay from the North Sea and turning it into a fresh water lake (Hoep, 2007). In January 1953, a storm surge in the southwest caused the worst flood in modern Dutch history, killing over 1800 people. This was a pivotal moment in Dutch water management history. In response, the Delta Act was passed to secure the Netherlands against future flooding. As a consequence there was a massive public investment in water management, including the Delta Works – a large-scale system finally completed in 1997 (Brouwer, 2015).

Implementation of the Delta Works was accompanied by a transformation in governance as government agencies including the Rijkswaterstaat consolidated power and local water boards merged, contracting from over 3500 in 1850 and over 2500 in 1950 to 21 today. Independent water boards provide a decentralized check on power in the Netherlands, and they have been credited with bolstering the Dutch resistance during World War II. However, their function has been questioned in a country where decision making is
already complicated by 12 provinces, over 400 municipalities, and multiple agencies dealing with water and infrastructure. Consolidation has accelerated since the passage of the 2009 Water Act which mandated management decisions follow watershed boundaries, which often cross multiple water boards and provinces (Brouwer, 2015).

The 2009 Water Act codifies integrated water management in the Netherlands and is the result of a major transition in Dutch water management, spurred by opposition to environmental degradation and a shift towards more participatory governance in response to the perceived failure of top-down decision making in the Delta Works project. This shift began after two near floods in 1993 and 1995 forced 250,000 residents to evacuate their homes. In response, the Rivers Delta Plan identified encroachment of development onto floodplains as a major risk. Higher dykes were opposed by environmentalists who pointed to the collapse of natural habitat and fish stock in bays and rivers walled off from natural fluctuations by the Delta Plan (Brouwer, 2015). The idea of ‘living with water’ was proposed as a way to use spatial planning and ‘calamity polders’ to create natural flood water buffers. In 2000, the first conceptual projects were presented under the name Room for the River along tributaries of the Maas River (Rijke et al., 2012). After years of planning, more than thirty Room for the River projects were allocated €2.2 billion in 2007 by the national government and became a testing ground for devolving leadership of implementation to provinces (Rijke et al., 2012).

In the early 2000s, the Dutch water transition began to accelerate through a series of policy measures promoting integrated water management and adaptation to climate change, including Room for the River (van der Brugge et al., 2005). Provinces were placed in a role as mediator between the national government, which sets policy and
provides the majority of funding, the Rijkswaterstaat, which implements large regional and national water projects, and municipalities and water boards, which build local flood control projects and provide water services (see Figure 4.1). These changes increased complexity in the governance system, codified in the 2007 Agenda for Living Countryside, which shifted planning authority decisions to provinces and water boards (Gupta et al., 2014).

In 2008, the 2nd Delta Commission assessed the long-term prospects of the Netherlands and placed a higher priority on increasing flood protection to cope with rising seas and larger storms projected by climate scientists. Reframing water as a climate problem introduced new challenges (Vink et al., 2013). Increased expense for more robust dykes and pumps left less money for relatively expensive natural, shared use solutions typified by Room for the River. Budget challenges combined with an increasingly complex decision making process exacerbated traditional conflicts between farmers and nature advocates. It also pitted Rijkswaterstaat bureaucrats, used to being authoritative partners in the construction of dykes and canals, against a growing wave of support for integrated water solutions. In 2010, the Delta Commission set out the first Delta Program, identifying the most immediate problems and allocating funding to provinces to address them. In 2011, an agreement to coordinate water management increased collaboration between municipalities, provinces, and water boards around fresh water supply and wastewater treatment. This has resulted in millions of euros saved and more active knowledge sharing (national water interview, June 24, 2015).

Throughout this period, technical research and experimentation on integrated water management solutions was advanced by Unie van Watterschappen (www.uvw.nl),
the national association of water boards, and Deltares (www.deltares.nl), an independent institute for applied research on integrated water management in deltas created in 2008 by the Dutch government. Deltares provides technical support, including hydrologic and economic modeling, for the Rijkswaterstaat, water boards, and 30 other countries through international partnerships. Unie van Watterschappen provides governance and technical advice on regional water management to water boards and to foreign countries under the auspices of the Dutch Water Authorities. Both work with academics and bureaucrats on applied research.

One result of this research is a new three layer approach to integrated flood management, framed as climate adaptive and developed in conjunction with Room for the River and the ‘living with water’ approach. It allows for some flooding by focusing on three layers of activity: (1) a base level of flood protection, (2) spatial planning and development, and (3) preparing for a behavioral response including evacuation and sheltering in place on high ground until floodwaters pass (van Herk et al., 2014). The third layer is based on emergency management practices common in the United States and is the focus of recent experimentation in cities like Dordrecht (Gersonius et al., 2016).
Studies of policy entrepreneurship in Dutch water management transitions document the pivotal role actors play in advocating for and facilitating policy change (Brouwer and Biermann, 2011). Brouwer and Huitema identify four types of strategies commonly employed by Dutch water policy entrepreneurs:

1. Attention- and support-seeking strategies, to demonstrate the significance of a problem and to convince a wide range of participants about their preferred policy, including three strategies, namely: the demonstration strategy; rhetorical persuasion; and the exploitation of focusing events strategy.
2. Linking strategies, to link with other parties in coalitions, projects, ideas, and policy games, again including three strategies, namely: coalition building; issue linking; and game linking.
3. Relational management strategies, to manage the relational factor in policy change trajectories, including the strategies of trust building and networking; and, finally, (4) arena strategies, to influence the time and place in which policy entrepreneurs act, including the strategies of venue shopping and timing. (Brouwer and Huitema, 2017)
The potential for learning through comparisons between policy entrepreneurship in multiple countries is a goal of this literature (Meijerink and Huitema, 2010). Though no specific professional role is identified amongst Dutch policy entrepreneurs for replication in other countries, stakeholder and participatory processes are recognized as important venues where policy entrepreneurs exert their influence (Brouwer and Huitema, 2017).

Edelenbos and colleagues have documented the rise (1999), initial implementation (2005), and complication of participatory processes in the Netherlands (Edelenbos et al., 2017). Research on the coproduction of knowledge (Edelenbos et al., 2011) and bottom-up processes (Roth and Winnubst, 2015) within Dutch water projects have demonstrated the positive impact expanding participation can have on innovation and successful implementation, i.e., widely accepted and effective projects. These researchers have also documented challenges, including problems that arise when conflict is removed from the process (Roth et al., 2017). Transition Management, introduced in Chapter 1, proposes a four step cyclical framework for facilitating transitions towards sustainability that has been applied in Dutch water management experiments (Rijke et al., 2012). Researchers also document the impact of a shift in policy discussions towards climate change risk management around 2008 (Vink et al., 2013). This increased focus on adaptation to sea level rise and flooding from storm bursts complicated earlier integrated flood management, but did not decrease the perceived need to engage in multi-level consensus driven participatory decision making (van Herk et al., 2015).
4.2.2 The Polder Model

The ‘polder model’ of Dutch democracy is characterized by consensus, compromise, and consultation with business interests. Recognized and praised by foreign observers in the 1980s and 1990s (Hendriks and Toonen, 2001) as participatory processes gained prominence in governance studies, including water management (Sabatier et al., 2005), it takes its name from poldering, the process of negotiation that developed around the creation of polders – networks of dykes and canals built to drain and protect farms and villages at or below sea level (Schreuder, 2001). The techniques developed in the Netherlands is the result of centuries of trial-and-error. This willingness to experiment and learn from failure is deeply embedded in the culture. For example, in Dutch schools it is expected that a large portion of students will initially fail. They are then given an opportunity to correct their work by rewriting a paper or retaking a test.32

Poldering now refers to any negotiation process in which multiple parties are expected to compromise around a mutually beneficial plan of action and includes distinct roles that support achieving consensus. In the Netherlands, consensus water management decisions are reached through horizontal consultation between public and private stakeholders and vertical consultation across government hierarchies. Unlike participatory processes in many other western democracies, at the start of a project a narrow set of stakeholders, including corporations, anticipated to be impacted is

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32 This cultural norm is particularly clear in Universities because of an influx of foreign students and professors following integration with the European Union. For example, a new professor from Italy used his standard grading practice and was informed by the University administration that he was passing too many students. If he did not fail more his classes would be perceived as too easy. Students would slack off and could not demonstrate that they were learning.
identified and explicitly engaged in decision making to increase the quality of information, build support for decisions, and increase legitimacy (Edelenbos et al., 2017).

Consensus can reduce conflict but also slow decision making because all parties need to agree on a proposed action. In response the strong Dutch central administration has developed an opaque process for finalizing decisions after consultation (Hendriks and Toonen, 2001). This opacity has created room for backroom deals that bypass what is officially a top-down hierarchical administrative structure inherited from 19th century Napoleonic rule. Backroom deals resulting in kickback scandals in the late 1990s led to an interest in the relatively open, adversarial Anglo-American approach to public decision making (Vink et al., 2015). It also increased reactive stakeholder engagement arising from “dissatisfaction with the actions of governments” and has emboldened to stakeholder groups to propose and champion alternative policies (Edelenbos et al., 2017).

Throughout this process, when negotiations begin to stall individual policy entrepreneurs step into an unofficial role, widely recognized in Dutch culture as a part of poldering: the oliemannetje. Literally the little oil man, the oliemannetje is the person who “puts oil on everything to keep the process flowing.” (interview #10, June 9, 2015) They are roughly equivalent to fixers or power brokers. Most large organizations have an oliemannetje to help wrangle support for politically sensitive or difficult projects. Universities often hire ex-politicians or well-connected bureaucrats as professors with the knowledge that they will provide oliemannetje services when necessary. Almost no references to oliemannetje exist in the English language academic literature, though one study of Dutch mayoral leadership styles calls an oliemannetje a ‘catalyst’ (Karsten and Hendriks, 2016). Generally, the term is considered slightly derogatory. It is recognized
that the oliemansnetje will use their influence and break rules to keep a project moving by subverting formal structures and working outside of official hierarchies. Despite ethical questions, the role is recognized as a helpful and desirable luxury. Essentially the only reason an organization or project would not have an oliemansnetje is because they are too expensive. They keep track of the politics and promote their patron’s interests, ensuring that the Dutch commitment to consensus does not lead to paralysis and inaction.

4.3 The Neo-Oliemansnetje

A neo-oliemansnetje is a professional policy entrepreneur who uses technical and political knowledge to catalyze policy change by working within and around existing governance hierarchies to promote risk taking and consensus decisions. In the Netherlands they are hired by governments or stakeholder groups to design and facilitate participatory water management processes. As third-party participants, they guide and legitimize the processes to accelerate policy change. Following sections describe the methods used in this project (4.3.1), define the neo-oliemansnetje (4.3.2), and present three examples of Dutch water projects facilitated by a neo-oliemansnetje (4.4).

4.3.1 Methods

The methodological approach employed in this research is qualitative and ethnographic. It involved unstructured and semi-structured interviews with Dutch water management professionals and academics in conjunction with participant observation as a visiting researcher at a Dutch university, between March and June 2015. Fourteen unstructured interviews were conducted with four professionals and ten academics beginning with the question of how stakeholders are engaged in the implementation of innovative Dutch water management projects. Notes from these interviews were used to
develop a set of questions and purposively identify experts for a second round of in-depth semi-structured interviews about the third-party facilitation of participatory water management projects, using a chain referral sampling technique (Bernard, 2006). Eight semi-structured interviews were conducted, six with professionals or government employees who support the implementation of local and regional water management projects involving stakeholder processes and two with academics who have studied and participated in multiple Dutch stakeholder driven water projects. Interviews ranged from 1 to 2 hours and were recorded. Questions developed for the semi-structured interviews aimed to understand who these professional policy entrepreneurs are and what they did to succeed (available in Appendix 1). Field notes and interview transcripts were analyzed through multiple readings to identify themes. Employing a version of Rapid Ethnography (Baines and Cunningham, 2013), emergent themes were discussed with colleagues who work in stakeholder processes in the United States to help identify culturally unique aspects of the Dutch approach.

Academic literature on stakeholder engagement in Dutch water management and policy transitions provided context for the ethnographic research, see for example Edelenbos et al. (2011). References in papers recommended by interview subjects, supplemented with google scholar searches of “Dutch water management” + “stakeholder” or “participant” resulted in a list of 76 relevant studies or government reports. Together these document experimentation with stakeholder participation and local decision making in Dutch integrated water management, which increased dramatically following policy changes in the late 1990s (Edelenbos, 2005). All of the
interview subjects, both professional and academic, conducted research on or participated in experimental water projects during this period.

4.3.2 Defining the Neo-Oliemmanetje

The role of neo-oliemmanetje is not official or explicitly defined. It is a role fulfilled by a variety of professionals within Dutch water projects including consultants, landscape designers, project managers, water experts, and engineers. What they share is an ability to facilitate consensus decisions within participatory processes by focusing on collaboration and mutually beneficial solutions, projects where “one plus one is three”. Part of the strength of a neo-oliemmanetje is a willingness to employ a combinations of tools with the skill to adjust as the process and participants evolve. Many individuals have the political or technical skills necessary to be a neo-oliemmanetje, but relatively few have both. Individuals with the appropriate skill set often have training in one area such as water engineering, water management, landscape architecture, or public administration and develop complementary skills through professional experience. It is common for professionals like neo-oliemmanetje in the Netherlands to complete a Ph.D. or other advanced degree while working. This allows them to increase their stature, develop relationships with academics, and feed their curiosity – a common trait in all of the professional policy entrepreneurs interviewed.

Successful third-party facilitators are particularly self-aware of their role in the process and recognize that water project negotiations in the Netherlands function simultaneously on multiple levels. “It’s like playing chess on multiple chess boards,” one

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33 “One plus one is three” is one of the most common phrases I heard from people in the Dutch water sector. It has achieved almost cliché status, but it is also taken seriously as the goal of every public project or public private collaboration.
consultant said, reflecting on an upcoming applied research project with the goal of identifying agricultural alternatives\textsuperscript{34} to dairy farming that could slow the rate of subsidence caused by peat collapse in Dutch Polders. Hired by the association of water boards, she would have to balance the egos of competing academics, farmers’ pride in their Holsteins - the most productive cows in the world, political conservatism, and general distrust of new ideas from water boards, farmers, and environmental NGOs. Balancing the politics of academics, bureaucrats, politicians, farmers, and environmentalists is often complicated by the fact that actions and statements made in one arena have repercussions for stakeholders in other arenas.

Neo-oliemannetjes recognize that parties come to the table with different priorities and questions. Their goal as facilitator is to help stakeholders articulate a shared problem and identify solutions that benefit everyone or at least do not leave anyone worse off. However, success ultimately depends on politics. The support of politicians, either for personal strategic or ideological reasons, is almost always necessary. Since politicians are often not directly involved in stakeholder negotiations, neo-oliemannetje use these skills to identify when a solution needs to be shared with particular politicians or bureaucrats who can support the project. To do this, they may identify specific participants in the negotiations or allies of the project to keep potential political champions or opponents apprised of the process. For example, interviewees mentioned using the head of a water board or well-connected senior consultant in their firm to step outside of the formal process and initiate conversations with politicians or bureaucrats on

\textsuperscript{34}The initial proposal included research on the viability of commercial cranberry cultivation in the Netherlands. The possibility of developing smaller cows was discussed but not thought of as a viable option because Dutch dairy farmers’ identities are heavily invested in Holsteins.
behalf of their project. This helps grease the wheels for future funding requests and allows the neo-oliemannetje to gauge support.\textsuperscript{35}

Though third-party facilitators are independent, everyone recognizes that the entity who pays has unique influence. This means that the third-party neo-oliemannetje must perform their independence as well as their loyalty to the employer. To do this, it is common to lay out the goals and initial proposals of the party that hired the facilitator. Then, the source of new ideas and each party’s willingness to compromise is clear. Demonstrating balance and independence may be another reason the facilitators make a point of highlighting co-benefits of any solution. Making benefits explicit shows exactly who is gaining from any individual proposal. As another demonstration of neutrality, Neo-oliemannejtes often work for small consulting or design firms or within special divisions inside of large international engineering firms like Arcadis or ARUP that are separate from the engineering companies that compete for infrastructure projects.

A tactic in performing neutrality is to avoid becoming the face of the project. The primary stakeholders may associate a neo-oliemannetje closely with the project, but in general they position themselves as advocates on behalf of the project rather than a representative of any single party or opinion. This was a lesson learned early in the career of one interviewee. After facilitating a multi-month river redevelopment process between municipal, provincial, and national government representatives, he presented the agreed upon design to residents in one of the towns. Despite highlighting economic and recreational benefits for the town and the region, the residents rejected the plan. They did

\textsuperscript{35} This process of working around hierarchies is also referred to as using a kruiwagen or wheelbarrow. It is an essential role of the neo-oliemannetje. Imagine moving sand from one side of a dyke to the other to ensure there is support where it is needed and your work does not get undermined.
not know him, and they did not trust that he was telling them the whole truth. From that point on whenever a planning process was opened up to wider participation, he carefully selected and coached a trusted community member from the initial stakeholder group to present the proposed plan (consultant interview, May 28, 2015).

A unique and important role fulfilled by neo-oliemannetjes is to identify when a project is unlikely to succeed. Attempting to implement a plan that does not have political or stakeholder support was compared to “pulling on a dead horse” (interview #23, May 20, 2015). Anotherneo-oliemannetje said it was their job to recognize when “one plus one is one-and-a-half” and point that out to the stakeholders (consultant interview, May 28, 2015). If a solution cannot be identified with sufficient mutual benefits and political support, then it can be stopped and resources diverted to other projects. This helps support experimentation by moving funds towards projects that are less likely to be blocked late in the process. Stopping a project in the Netherlands, even if a promising solution has been proposed, is a viable option partially because bureaucrats tend to stay in their job and can try the solution again when it is more politically viable. An independent neo-oliemannetje, loyal first and foremost to addressing a problem, feels free either to encourage stakeholders to try another more mutually agreeable solution or move on to another project.

In addition to managing planning and implementation of water projects, neo-oliemannetjes are hired to facilitate applied research on specific questions, such as how to slow soil subsidence in agricultural polders or how to encourage Dutch residents to take individual protective action against flooding, and when this research identifies viable solutions they help implement demonstration projects. Funders are attracted to these
demonstration projects because they can take risks on experimental approaches and claim ownership of successes but maintain distance from failures. If a project is jointly funded this enables multiple parties to claim success and then replicate successful innovations.

Through these projects, neo-oliemannetjes also play a role in fostering collaboration between academics and government entities including water boards, provinces, and cities. Neo-oliemannetjes, and government water experts, are regularly engaged to give guest lectures at universities. They invite academics to participate in research projects or advise planning processes on new techniques. Relationships are maintained through regular in-person meetings. It is common to have two or three short meetings a week with professionals or academics not directly involved in their immediate work. The focus on networking and relationship building helps maintain communication and creates opportunities to pursue new solutions when an existing pathway fails to workout. It is an essential part of the Dutch trial-and-error approach to problem solving.

4.4 Examples

I use three examples from water management projects in the Netherlands to illustrate how third party neo-oliemannetjes help guide difficult projects to implementation. In each project, the neo-oliemannetje was hired by a different party at a different point in the process. In the first example, Overdiepse Polder, an outside water expert was hired by a group of farmers who were being forced to move off their land. In the second example, the city of Rotterdam hired an urban design firm to facilitate the planning and construction of water squares, urban plazas that double as stormwater storage for large rain events, after a city led pilot project failed. In the third example, two provinces and five water boards hired a neutral third party to facilitate their
implementation of a regional integrated water supply plan in response to higher flood protection standards mandated by the national Delta Program. These three cases demonstrate how the role of neo-oliemannetje has emerged over the past two decades in response to stakeholder conflicts caused by the increased complexity of adaptive water management in the Netherlands.

4.4.1 Overdiepse Polder – Bottom-up Initiation

Overdiepse Polder in the province of Noord-Brabant was one of the last polders occupied in the Netherlands. Settled by farmers in the late 1970s, it is a 2 square mile (550 hectare) island along the Bersche Maas River 15 kilometers from the city of Den Bosch, home to less than 100 people and many more cows. In an attempt to protect valuable urban and industrial areas from flooding, the national government suggested a buyout of the entire polder in 2000 as one of the initial Room for the River project. In response, the Overdiepse farmers took advantage of the Rijkswaterstaat’s first attempt at delegating flood planning to a province to inject their voice into the process and push for an experimental solution (Roth and Winnubst, 2014). The residents formed the Overdiepse Polder Interes Group (OPIG) and hired a water expert to negotiate for them in the planning process. A spatial planning NGO worked with the farmers’ expert to organize design workshops in 2002 that led to the idea of creating terps – elevated mounds for critical infrastructure like houses and barns historically used by the Dutch before large dykes were built. In the final plan about 2/3 of the farmers were enabled to remain and live on terps, allowing areas of the polder to flood periodically, approximately once every 25 years. This reduced the river’s maximum flood height, and by association dyke heights, by 27 cm (Roth and Winnubst, 2014).
It took another six years for the provincial and national government to agree to the plan, and the first terps were finally built in 2013. Throughout this process, OPIG’s water expert, paid for with Room for the River funds, played a critical role connecting provincial politicians who supported “creating space for water” to the project while advocating for the farmer’s interests from a technical perspective within the planning process (academic interview, April 20, 2015). He helped build trust between the province and the farmers and maintained support for the terps approach when conflict arose between farmers around terms of the buy-out for those who would be leaving the polder. Critically, when farmers were excluded from participating in official steering committee meetings between the province and Rijkswaterstaat, their expert was allowed to observe and then became an official advisor after impressing the committee with his advice (Roth and Winnubst, 2015). Additionally, he provided continuity when the first provincial project manager, perceived by farmers as opposed to the terps solution, was replaced in 2006 (Roth and Winnubst, 2014).

The story of Overdiepse Polder has been written up in the New York Times (Kimmelman, 2013) and packaged by the Dutch government in promotional materials that have been shared around the world. It has been described as a revolution in governance, but in reality it was a highly contextual decision that took years of careful and strategic planning (Roth and Winnubst, 2014). The farmers’ expert used his skills to create space for experimentation and new governance arrangements during a time when changes in water management were perceived as desirable, but alternative pathways for including marginalized parties like the farmers in negotiations were not established. Stretching over a decade, the pathways and experiments initiated by the farmers and their
neo-oliemannetje helped set an example for previously unimagined governance relationships. The Overdiepse Polder success gave advocates of increased participation and bottom-up processes a powerful example and helped catalyze an accelerated period of change in Dutch water governance. Demonstrated in the third example below, the province of Noord-Brobat has taken lessons from the experience in Overdiepse in its management of larger, multi-jurisdiction climate adaptive water projects.

4.4.2 Rotterdam Water Squares – In Response to Failure

As part of a city wide climate initiative Rotterdam pioneered the use of water squares or water plazas, redesigns of paved public open spaces into multi-use recreational areas that are usually dry but provide temporary rainwater storage during large storm events (Biesbroek et al., 2014). The first water square, finished in 2013 in Benthemplein, was designed through a participatory process facilitated by De Urbanisten, a Rotterdam
based urban design firm, and has been publicized around the world as a demonstration of the city’s commitment to innovative climate adaptation. However, this was not the city’s first attempt at a water square. A pilot project was designed by city engineers for Bloemhofplein but was rejected by residents in 2009 and led the city to hire a third-party facilitator (Biesbroek et al., 2014).

The rejection came as a surprise for city staff. Designs were shared in two public meetings. The first was attended primarily by older Dutch residents who generally approved, however the second meeting was attended by a group of immigrant mothers, many from Morocco, who became concerned about the risk of their children drowning in a playground that could rapidly fill with water. This opposition may have been exacerbated by the city’s attempts in previous years at participatory planning in the neighborhood that ended poorly. As a city employee said, residents were asking “why should we accept it? [The city] decides what’s coming, how it’s gonna be built, when it’s gonna be built. All is ordered by the city.” (city employee interview, April 21, 2015).

Despite multiple attempts to include residents in a redesign and offers of swimming classes for all children distrust grew, and eventually political support for the project collapsed (Biesbroek et al., 2014). An internal review of the failure determined that future water square projects needed to be managed by a clear “principle agent”, engage earlier with residents, and respond to resident concerns throughout the process (Bressers and Edelenbos, 2014).

De Urbanisten, the design firm that first proposed the water square concept, was hired to facilitate the project at Benthemplein, a square next to a school where students had requested more recreational facilities. A designer from De Urbanisten worked to
build trust with stakeholders and created a space for positive interactions between the city and residents. At each of three workshops during the year-long design process, approximately 25 stakeholders including residents and students helped design the water square, starting from a blank sheets of paper with only the neighboring buildings drawn in (Bressers and Edelenbos, 2014). The firm helped raise participant concerns with the city, and built consensus around co-benefits including better recreation, decreased flooding, and climate resilience. This work was championed by city staff working on the Rotterdam Climate Initiative$^{36}$ who helped maintain political support for the project, creating a sort of collaborative neo-oliemammetje with the design firm.

The success of the Benthemplein process changed the way Rotterdam approached the design of future water squares, as well as other projects. Rotterdam has begun regularly hiring third-party facilitators for projects like The Blue Corridor – an ambitious 20-year scheme to build a new waterway, in partnership with multiple municipalities, the province, and the local water board, that will combat saltwater intrusion by bringing a new supply of fresh water to the southern part of Rotterdam and create a new recreation trail. Aware of the challenge posed by coordinating the interests of all of the impacted parties, Rotterdam recently hired De Urbanisten to facilitate the design and implementation of a new section, using a process beginning with the identification of co-benefits for all participants. This third-party facilitation increases legitimacy for the project and helps attract co-funding from partner municipalities (city employee interview, April 21, 2015). Rotterdam provides engineering support and primary funding, which allows it to set basic parameters and have a decisive say in the final design.

$^{36}$ http://www.rotterdamclimateinitiative.nl/
4.4.3 Noord-Brabant – Planning Ahead

The 2010 Delta Program mandated increased flood protection levels to account for anticipated future climate change. The plan included redirection of waterways in the province of Noord-Brabant, impacting the supply of fresh water across a local watershed that includes areas of the province of Limburg and five water boards. Potential impacts identified by Deltares water models included insufficient water supply for farms in sandy highlands during droughts and saltwater intrusion, which could negatively impact urban and industrial water supplies. In their effort to identify a solution, the seven key stakeholders led by Noord-Brabant hired a neutral third-party to facilitate the planning and implementation of a climate adaptive regional water supply plan. This proactive

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37 This case is sourced from interviews with a consultant and provincial employee conducted on June 24, 2015.
The individual hired to manage the project works for a small consulting firm that focuses on support for water projects. Trained in public administration, he developed technical expertise in water through work with public servants designing components of the Delta Program, also the subject of his Ph.D. which he pursued in conjunction with work. He entered the project following three years of preliminary negotiations and set up meetings with key stakeholders from impacted provinces, municipalities, and water boards. In these meetings co-benefits were articulated and stakeholders committed to goals, a decision making process, and a timeline. Informal side meetings and discussions were common throughout the process. Eventually projects were decided upon and support from national agencies and ministers was pursued. The project manager checked in on a regular basis, often weekly, with participating provincial, municipal, and water board staff to identify progress and emerging problems. He also made it clear that staff and stakeholders could come to him with issues and concerns. Calling out obstruction and lack of cooperation was an important part of facilitating this project, particularly between departments within the provincial government of Noord-Brobant. Though staff was generally enthusiastic about collaboration and would regularly meet with counterparts at water boards, they would avoid talking to colleagues in other departments about critical components of the project until confronted by the project manager.

One exciting development in this project was the transfer of leadership skills from the project manager to government staff. The multi-layered governance around this project was new to many provincial staff. They asked, “what is our role if we aren't a
dominant actor anymore?" Rather than tell them how to negotiate these new
arrangements, the project manager began coaching staff to recognize and engage conflicts
that arose around the project, first with external partners and then internally within the
provincial government. This enabled staff to establish new venues for interaction and
create space for partners to initiate actions that were previously “bleeding to death” from
the weight of provincial dominance. Implementation of the regional water supply plan is
ongoing, and the collaborative process quickly resulted in project-wide coordination
around small investments that would otherwise have been made in isolation, likely
resulting in duplicated effort and lost co-benefits.

4.5 Principles of Neo-Oliemannetje

Understanding the role of neo-oliemannetje is valuable because it is potentially
transferable outside of the Netherlands. First, even though it has been refined in the
Netherlands over the past 15 years, this role is not unique to the Netherlands. Most
societies have fixers who work around the system to make things work, just not usually in
adaptive water management as a professional third-party. Second, water governance
systems vary from region to region, but in all of these regions climate adaptive decisions
necessitate cooperation to identify and implement mutually beneficial solutions.
Therefore an individual who can engage complex negotiation processes in a way that
facilitates consensus and realizes co-benefits will have value. To replicate the neo-
oliemannetje in other countries, it is necessary to identify the principles that are necessary
to fulfill the role. This section identifies three actions that a neo-oliemannetje performs,
three skills they need to perform those actions, and four things governments or
stakeholders do to support a neo-oliemannetje to facilitate a successful process.
4.5.1 Actions

In interviews, three actions were repeatedly attributed to third-party facilitators or neo-oliemennetje (Table 4.1). First, they work to facilitate collaboration by defining the structure and terms of the project so that all participants are on the same page. As part of this they make space in the process to engage or invite new participants when that is advantageous for the project. For example, if a groundwater expert is needed they would find an expert and in addition to providing the details of the project and the scope of the question they would work to minimize conflict with any academics already involved in the process. Second, they articulate the co-benefits of any proposed actions. To do this they first elicit the needs and goals of the project stakeholders, a core component of polder negotiations, and then highlight how particular solutions will be mutually beneficial. For example, if a proposed solution does not provide a direct benefit for one party or stakeholder they articulate how it will benefit others without harming them. Third, they act as an oliemennetje and a policy entrepreneur. They maintain momentum in the project by working within and outside institutional hierarchies and formal governance structures to overcome political, interpersonal, and technical barriers. For example, if they see a window of opportunity to try a promising new solution to a problem, they help gather political and financial support for a demonstration project. Additionally, if too many problems arise and they do not believe a viable solution can be achieved they advise their employer to stop and redirect their resources elsewhere or wait and try again later. Through these actions, neo-oliemennetje demonstrate their independence, increasing legitimacy and positive participation in the project.
<table>
<thead>
<tr>
<th>Actions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate collaboration</td>
<td>Define the structure and terms of the project so that all participants are on the same page and new participants can be engaged when necessary.</td>
</tr>
<tr>
<td>Articulate co-benefits</td>
<td>Elicit the needs of individual parties and highlight how solutions are mutually beneficial.</td>
</tr>
<tr>
<td>Be an oliemannetje/policy entrepreneur</td>
<td>Grease the wheels to maintain project momentum. Work within and outside institutional hierarchies and formal governance structures to overcome political, interpersonal, and technical barriers.</td>
</tr>
</tbody>
</table>

Table 4.1. Actions performed by neo-oliemannetje to catalyze policy change.

4.5.2 Skills

Neo-oliemannetjes share three skills that they use to successfully facilitate projects (Table 4.2). First, they have a foundation of technical knowledge that allows them to speak with and understand participants in the process. Technical skills legitimize neo-oliemannetjes with technical professionals like academics and engineers and enable them to communicate accurate technical information to non-technical participants. Technical knowledge is also necessary for a neo-oliemannetje to recognize gaps in understanding and then bridge those gaps.

Second, a neo-oliemannetje needs the political savvy to anticipate and respond to conflict between and within stakeholder groups. They build coalitions, advocate for multiple perspectives, and track political support or opposition to maintain project momentum and avoid wasted energy or resources. They do this by cultivating contacts amongst politicians, bureaucrats, and academics. For example, before a potentially controversial solution is proposed or a demonstration project is pursued, the neo-oliemannetje will look for support at “another level” outside of the project stakeholders (interview #23, May 20, 2015). This support may be from a local or national politician or an influential bureaucrat. Rather than ask for that support directly, a neo-oliemannetje
may ask a stakeholder such as the head of the local water board to share their project’s progress and look for support from a specific individual.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical knowledge</td>
<td>Technical skills relevant to the project enable the neo-oliemannetje to understand participants and communicate technical considerations when knowledge or understand gaps exist. In addition to functional benefits this builds trust between parties.</td>
<td>Landscape designers in Rotterdam used their design skills to integrate the city’s technical needs and students’ recreational desires for the proposed water square, providing translation where necessary.</td>
</tr>
<tr>
<td>Political knowledge</td>
<td>A neo-oliemannetje needs the political savvy to observe and respond to conflict between and within institutions. They build coalitions, advocate for multiple perspectives, and track political support or opposition to maintain project momentum and avoid wasted energy or resources.</td>
<td>Recognizing that the Rijkswaterstaat was not trusted by local residents, the neo-oliemannetje had a well-known local municipal council member who participated in decision-making present the plan for a new canal.</td>
</tr>
<tr>
<td>Project management</td>
<td>Strategically managing the project is the main task of the neo-oliemannetje. Tasks include establishing a timeline and decision making process, identifying participants at different stages, facilitating meetings, choosing venues, setting communication strategies, identifying co-benefits, seeking additional support, calling out bad actors, and ending the project if necessary.</td>
<td>In Noord-Brabant, the neo-oliemannetje documented commitments from all parties. If actions were not finished on time or resources were not provided as promised, he would ask what was not working and look for a solution.</td>
</tr>
</tbody>
</table>

Table 4.2. Three skills commonly used by neo-oliemannetjes.

Third, neo-oliemannetje have excellent project management skills. Strategically managing the project is the main task of the neo-oliemannetje. Project management includes establishing a timeline and decision making process, identifying and engaging participants at different stages, facilitating meetings, choosing venues for demonstration
projects and presentations, setting communication strategies, ensuring co-benefits are clear, seeking additional support, calling out bad actors, and if necessary ending the project. Neo-oliemannotje take individual approaches to project management and adjust depending on a project’s needs and their role. For example, some neo-oliemannotje are hired as a project managers, so project management is a clear expectation and central component of their work on the project. For a landscape designer hired to facilitate a participatory water square, they may have to manage from behind by coordinating with city staff assigned to oversee the project.

4.5.3 Project Support

Governments, NGOs, and stakeholder groups support neo-oliemanetje in multiple ways, including the following four forms of support that are important in the success of Dutch participatory water management projects (Table 4.3). First, a clear goal is set to address a specific problem. This defines the scope of the project and helps participants stay on track. Second, boundaries are established at the beginning including timeframe, geographic area, and essential participants. These boundaries are usually recognized as negotiable and open to adjustment as the project evolves. Third, financial support is available not only for the planning and negotiation process but for implementation of demonstration project or possibly full implementation. Financial support does not have to be allocated before the process starts, but an avenue for future funding is important. Finance is the most common barrier to implementation of adaption projects (Hughes, 2015), and without the potential for a project to be implemented stakeholders are unlikely to fully engage in planning exercises. Fourth, neo-oliemanetje are held accountable. When a neo-oliemanetje is hired they are provided with clear
expectations and regular performance reviews. In the Netherlands it is common for neo-oliemannetje to be hired for a short period, e.g., 6 months or 1 year of a multi-year project, with renewal contingent upon support of key stakeholders. This makes the neo-oliemannetje loyal to the success of the process as well as the project.

<table>
<thead>
<tr>
<th>Project Support</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>Identify a specific problem to be addressed.</td>
<td>Demonstrate water squares as a new form of infrastructure that increases both stormwater capture and public amenities.</td>
</tr>
<tr>
<td>Boundaries</td>
<td>Establish time (e.g., months or number of events), geographic, and essential participants.</td>
<td>Facilitation of three design workshops and construction of a water square at Benthemplein that will engage stakeholders and residents who use the plaza.</td>
</tr>
<tr>
<td>Financial support</td>
<td>Provide monetary support for the planning process as well as experimental implementation of agreed upon solutions.</td>
<td>Rotterdam provides a budget for designing the water square, engineering support and a separate construction budget to build the final design.</td>
</tr>
<tr>
<td>Accountability</td>
<td>Agency, government, or organization that hires a neo-oliemannetje provide clear expectations and provide review.</td>
<td>Following the three workshops, if city staff and stakeholders approve the designer will continue to facilitate construction.</td>
</tr>
</tbody>
</table>

Table 4.3. Four steps organizations can take to support a neo-oliemannetje.

4.6 Conclusions

The role of neo-oliemannetje is a product of changes in Dutch water management over the past two decades, emerging out of a specific cultural and governance context made more complex by climate change. These third-party professionals, from a variety of formal backgrounds, play an important role in catalyzing the ongoing Dutch transition towards integrated, adaptive water management. By understanding what their work is and
how they do it lessons can be extracted and transferred to other vulnerable regions, including South Florida.

Though it is problematic to treat solutions developed in one country as universally applicable (Zegwaard et al., 2015), it is useful to consider new solutions as cultural innovations that can, if understood contextually, be transferred across cultures and landscapes – the same way we do with other technological innovations. The United States is a natural place to explore the use of neo-oliemannetjes. The Netherlands and the United States have a shared history of water management. Historically, these two countries spend more on water management, particularly flood management than any others, and they regularly exchange knowledge on water issues (Kolen et al., 2012). Both have undertaken major water projects that fundamentally shaped their societies, and both cultures are the product of responding to disasters, massive floods that killed thousands have been motivators or as the Dutch water managers like to call them “funding opportunities” (Bijker, 2007).

In the American system, it is not uncommon for an agency or government that convenes a collaborative decision making process to hire a facilitator. Providing that facilitator with specific objectives and resources, see section 4.5.3, could increase the likelihood of successful implementation of climate adaptation projects. However, hiring an experimental neo-oliemannetje may be difficult for local governments. Beyond justifying the added cost, it is likely that implementing the role of neo-oliemannetje in the United States could be perceived as disruptive because it would require bringing increased attention to process, power arrangements, and consensus based collaboration. One potential solution is for NGOs to take on the role of hiring a neo-oliemannetje in
agreement with local governments. For NGOs or other non-governmental stakeholders, hiring a neo-oliemannetje is essentially hiring a policy entrepreneur to represent your interest in finding a new solution to a difficult problem. However, this will only work if neo-oliemannetje are empowered to go beyond lobbying for a specific party and help facilitate co-beneficial solutions to an agreed upon problem.

The response to sea level rise in coastal communities in South Florida could be a testing ground for the use of neo-oliemannetjes in the United States. Local governments must work with private property owners, county and municipal governments, state transportation and water management agencies, as well as federal agencies including the Army Corps of Engineers. Fostering support for experimentation with local, state, and federal partners is important so that permits can be expedited and funding coordinated, as was the case in Miami Beach (see Chapter 3). A barrier to transferring the neo-oliemannetje concept is the need for trusted local water experts with both political knowledge and technical skills. Fortunately, the Southeast Florida Climate Change Compact (the Compact) has developed a network of well connected, trusted, technically knowledgeable experts familiar with the political landscape (Vella et al., 2016) who could potentially fulfill the role of neo-oliemannetje. The Compact could pursue grants to employ an experimental third-party neo-oliemannetje position in partnership with a county or municipal government to facilitate participatory implementation of portions of its second Regional Climate Action Plan, currently under development with stakeholders.

Dutch academics have conducted some of the most in-depth research on policy entrepreneurship, including a recent survey of all 339 Dutch water policy entrepreneur working identified as working in local government (Brouwer and Huitema, 2017).
Identification of the role of neo-oliemannetje suggests that their research could be expanded to include professional third-party facilitators, likely a group of less than 100 individuals working at 10 to 20 firms. They could use this to identify differences in strategies, demographics, and educational backgrounds. Most policy entrepreneurs working in government are male engineers, whereas professional facilitators may have a more diverse background. Differences could also be identified between how public government policy entrepreneurs and neo-oliemannetjes in how stakeholders are selected, goals are articulated, and co-benefits are identified throughout the process. Additionally, Dutch researchers could look for the presence of neo-oliemannetjes in other sectors. If it is a cultural product, it seems likely that neo-oliemannetjes could exist in other areas such as energy and health care that have experienced technological and governance transitions (Loorbach and Rotmans, 2010).

Transition Management is an approach designed by Dutch researchers to help accelerate sustainability transitions through experiments that follow a four stage cyclical process of strategizing, setting tactics, operationalizing experiments, and reflecting or assessing (Loorbach, 2010). It has been successfully applied primarily in the Netherlands, and though the four stages have been identified in water management (Brown et al., 2013), urban adaptation (Mees, 2016), and agricultural (Park et al., 2012) cases around the world. Neo-oliemannetje often follow processes of identifying shared problems, proposing solutions, experimentation, and assessment similar to the four stage cycle prescribed by Transition Management. This raises at least two questions that could be studied in future projects or analyzed in past implementations of Transition Management.

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38 Aggregated from estimates by interviewees.
What role do policy entrepreneurs play in Transition Management? Transition Management has been found to encourage “extra-institutional” democratic practices (Jhagroe and Loorbach, 2015). Does the presence of a professional third-party facilitator/neo-oliemannetje create space for new governance arrangements?

This chapter describes a version of neo-oliemannetje that will need to be adjusted for a range of governance and cultural settings, providing opportunities to understand what is essential in a neo-oliemannetje. In the case of Rotterdam, city staff provided vital support for the third-party designer who helped implement the watersquares. For example, the need for a single individuals to fulfill the role of neo-oliemannetje could be tested in these new settings.

Local governments have begun to hire resilience officers tasked with coordinating the local response to climate change, for example Miami, Miami Beach, and Miami-Dade County (Chapter 3). Measuring whether these individuals can reduce the gap between the adaptation a community could take and what it is doing is an area of active research (Chen et al., 2016). In South Florida, chief resilience officers can fulfill some of the services of a neo-oliemannetje, such as facilitating collaboration and highlighting co-benefits, but they cannot provide third-party legitimacy. To measure the importance of third-party status, future research could measure the adaptation gap in cities with resilience officers, like Miami, and compare the impact of projects where a third-party facilitator is present with projects led primarily by city staff.

The power of the neo-oliemannetje comes from the flexible of their position. They embrace creativity and are willing to subvert established ways of working in pursuit of innovative solutions. Entrepreneurial individuals working on water issues are probably
already fulfilling the role of neo-oliemannetje. Who is a neo-oliemannetje, where they act, and their potential impact is limited more by knowledge of the role and lack of funding for third-parties than the lack of a formal positions.
Chapter 5
Conclusions
Recommendations for Local Governments and Collaborative Future Research
5.1 Overview

The potential benefits of adapting to climate change have been clearly articulated (Adger et al., 2005; Bierbaum et al., 2013b), however in practice adaptation is messy and defies theoretical categorization (Preston et al., 2015). Successful adaptation advances through clumsy attempts to address future impacts despite deep uncertainty and incomplete information (Dilling, 2015). Even when climate impacts are predicted in a general sense they can unfold unexpectedly (Bazerman, 2006) and require innovative solutions. Trial and error is the best worst option to address the new, unfamiliar problems created by climate change (Broto and Bulkeley, 2013; Farrelly and Brown, 2011).

This means that vulnerable communities must embrace experimentation in the context of limited resources and time. As sea levels rise, coastal adaptation is only going to get harder and more expensive (Hallegatte et al., 2013b; Hinkel et al., 2014). Despite academic research and planning efforts, local governments struggle to implement actions to reduce their risk (Betsill and Bulkeley, 2007; Hughes, 2015; Loorbach et al., 2015; Woodruff and Stults, 2016). Collaboration between academics and professionals can help address the mismatch between available climate science and the needs of practitioners – including local governments (Lemos et al., 2012). Analyzing risk can reveal conceptual misunderstandings between practitioners, researchers, and stakeholders that result in barriers to decision making (Dobbie and Brown, 2014).

The broad goal of this dissertation is to understand South Florida’s response to sea level rise and support efforts to decrease the gap between what communities are doing now and what they can do to reduce their exposure to risk. It remains an open question whether local governments in South Florida, and around the world, will be able
to rapidly deploy resources in an effective, efficient, and equitable manner to adapt to climate change. The success of future research should be measured by whether it helps vulnerable communities like South Florida adapt. The timeframe to respond to climate change is decreasing, and communities need to reduce their exposure to climate impacts by seizing opportunities to rapidly implement policy experiments, which are necessary to transition into a more sustainable use of resources (Farrelly and Brown, 2011). These periods of accelerated change occur when physical, political, and institutional forces align and are the result of concerted efforts by key actors (Hughes et al., 2013; Meijerink and Huitema, 2010).

Understanding the process of adaptation, guiding it, and scaling up successes will take collaboration between academics and stakeholders. Stakeholders engage with the adaptation process at different levels of intensity over time. Success will come from listening to participants, recognizing perspectives, and responding to the risks that stakeholders voice as real and valid concerns which threaten but can also enhance the process of adaptation (Akerlof et al., 2017). This was the case in Miami Beach when opposition to a pump-only solution led the City to consider elevating streets (Chapter 3). Collaborative research using new tools like immersive simulations (Chapter 2) and third-party facilitators (Chapter 4) can help local governments and stakeholders articulate and apply the risks that matter most to them to guide adaptation.

This final chapter summarizes the results of the previous three chapters, then building on those results presents four practical recommendations for South Florida to help catalyze the regional response to climate change. Along with each recommendation,
future research is identified that could support its successful implementation, particularly if conducted in collaboration with local practitioners.

5.1.1 General Findings

Optimistically, the conditions in South Florida are conducive for investments in proactive adaptation that reduce exposure to sea level rise. In the immersive simulation presented in Chapter 2, over 70% of South Florida homeowners, the most invested and vulnerable residents in the region, are willing to support higher taxes to pay for adaptation, though they are not yet concerned enough to prioritize and push for it. The public response in Miami Beach confirms this finding, see Chapter 3. In 2014, residents supported higher fees to fund a $100 million climate adaptive stormwater investment and re-elected the mayor a year later on a platform of continued spending increases.

Unfortunately, as the costs and inconveniences of persistent sea level rise increase and homeowners learn more about the projected impacts, within the simulation experiment in Chapter 2, they grow more concerned and their willingness to move out of the region increases significantly. This pattern of worry increasing with sea level rise is consistent across age, income, political identity, and other demographic divisions. Though individual groups start at different levels of worry and willingness to move, they all increase over time. This suggests that there is a limited window of opportunity for local governments to respond before residents lose confidence and external forces such as increased insurance rates, decreased bond ratings, changes in the National Flood Insurance Program, and changes in global investment patterns make it more difficult for South Florida to adapt.
Miami Beach provides a useful example for local governments interested in a proactive response to sea level rise. With political will and community support it was able to successfully invest its resources in adaptive infrastructure and policies. However, these adaptation investments did not come without controversy. By identifying the risks that were most important and responding to stakeholder concerns, the city was able to prioritize its response. These findings were identified using the newly developed Urgency, Barriers, and Risk (UBR) Framework. Beginning from definitions of risk identified within the adaptation process, UBR describes the mechanisms that enabled Miami Beach to recognize and respond to barriers as they arose within the adaptation process. It advances the study of adaptation by introducing a structure for tracking and analyzing the interaction between pressures driving policy change, decision makers, and barriers dynamically within the adaptation process.

Using the UBR framework, three lessons were extracted from the experience of Miami Beach. (1) Barriers appeared towards the end of the agenda setting phase and early in implementation, when newly engaged stakeholders recognized and opposed specific adaptation actions. (2) Facilitation provided by city staff and the chair of the Blue Ribbon Panel enabled the city to respond to barriers. (3) Adaptation actions that address sea level rise risks at multiple timeframes were more successful.

Managing the process of adaptation, especially the initial transition away from business as usual, took both technical skills and political savvy from members of the Mayor’s Blue Ribbon Panel and city staff. Replicating that success outside of Miami Beach is not straight forward because local knowledge was essential for building legitimacy across stakeholder groups, and the Panel was learning on the fly (interview,
February 2, 2017). Fortunately, South Florida can look to the Netherlands for guidance on how to facilitate difficult, experimental climate adaptive water management projects. Chapter 4 introduced the neo-oliemannetje, a third-party facilitator who builds consensus by articulating co-benefits and steps outside of traditional structures when necessary to maintain a project’s momentum. The skills employed by the Dutch neo-oliemannetje are already present in South Florida, as documented by the work of the Blue Ribbon Panel in Miami Beach. The challenge is making the use of those skills a pervasive cultural norm within the regional response to sea level rise.

5.2 Recommendations for Local Governments

Based on the findings presented in this dissertation, the adaptation literature, and observation of the region’s respond to sea level rise over the past five years, four recommendations are made for governments in South Florida as they adapt to sea level rise and climate change. The first two can be addressed by individual cities or counties, and the second two require regional collaboration. Communities in South Florida are connected hydrologically, economically, and physically by vulnerable infrastructure and ecosystems. The region is threatened by hurricanes, recessions, corruption, and poor planning. If only functional, wealthy communities respond effectively and efficiently to the looming crisis of sea level rise, regional adaptation gaps will appear and vulnerable communities, like flood prone middle and low income cities in western Miami-Dade county (Chakraborty et al., 2014), could be left behind. This pattern of unequal investment may be exacerbated by the finding in Chapter 2 that middle income residents, who may be most invested in their homes as a percentage of their wealth, are the least worried and least willing to move.
5.2.1 Recommendation 1

Seize the window of opportunity. Do not wait for residents to begin abandoning the region. The simulation in Chapter 2 demonstrates that homeowners are willing to support investments in adaptive management. Investments in flood management are only going to get more expensive as time passes, development continues in low areas, and sea levels rise (Buchanan et al., 2016; Hallegatte et al., 2013a). Academics and the mayor of Miami Beach agree, there is no time for “analysis paralysis” because the future is shaped by our actions today (Fincher et al., 2015). As the chair of the Blue Ribbon Panel said, Miami Beach had to take action so that the city “wouldn’t disappear before we recognized the problem.” He learned a lot through the process, and now that he knows the risk his city faces is “more afraid” than when he started (interview, February 21, 2017).

5.2.1.1 Future Research: Immersive Simulations

Immersive on-line simulations provide a promising platform to motivate resilient thinking and behavior and to pre-test new adaptation measures. The study in Chapter 2 demonstrates that they can reduce the distance residents of South Florida feel from future sea level rise. The question is, does participating in simulations and immersive experiences that help people imagine what life would be like with higher sea levels change attitudes and behavior in real life today? Future research can engage Miami residents in simulations of sea level rise and track their attitudes longitudinally over time. Measuring the relative rank of perceived risks (e.g. short-term nuisance flooding versus
long-term inundation) and how rankings shift over time could answer whether the issue is crowded out in a finite pool of worry (Weber, 2006) or caused by a lack of worry due to psychological distance (Spence et al., 2012). In-depth follow up interviews with a sample of the simulation population can help identify what motivates risk perceptions and behaviors.

Future simulations using the *Choice Flow* platform or similar tools in collaboration with local governmental partners could support risk identification and experimentation. Functioning as a form of trial and error, simulations can help local governments increase the likelihood of implementation success. They can be used to model perceived risk in stakeholders, response to novel adaptation measures, and the rise of barriers to those measures. Additionally, the simulation itself may be an effective educational tool to communicate clear, specific risks and mitigation measures to unify risk perceptions across decision makers.

The limited impact of traditional experimental manipulations like framing in the experiment in Chapter 2 suggest that future simulation studies can keep manipulations to a minimum and instead use resources to focus on creating rich scenarios and environments in which participants actively curate their own experience. Thus, widespread use of simulation experiences, including augmented and virtual reality, like the Sustainable Behaviors project at Stanford’s Human Interaction Lab, have the potential to increase individuals’ ability to engage with future climate risks.

These rich simulation environments could be paired with targeted experimental manipulations. The UBR framework, introduced in Chapter 3, provides a structure that can be tested in future simulations. It longitudinally connect risks to adaptation actions
and stakeholder response using an extension of the Relational Theory of Risk (Boholm and Corvellec, 2011) and provides an opportunity to research how risks are constructed over time within a relatively realistic decision environment. Experimentally controlling the probability, pathways, and timeframe within the relationship between the value and threat that make up a risk could uncover what makes a specific risk salient to different community members. This would have practical value for risk communication and theoretical value for risk research that has struggled to identify mechanisms connecting individual risk preferences to group decision making (Boholm, 2015).

By breaking down the risk relationships within a messy adaptation process, theoretically driven hypotheses can be tested. Construal theory predicts that more distant threats or risks will be treated more abstractly (Trope and Liberman, 2003), suggesting that risks with more distant or ambiguous time components will result in more abstract pathways of connection. For example, in Miami Beach initial conversations on the Blue Ribbon Panel focused on multi-foot sea level rise, more than 50 years in the future, and the impacts discussed were abstract, including widespread property value losses from general flooding across the island. When the Panel turned to short term risks and determining where to invest money, it focused on specific measurements like street elevation and concrete impacts like recent flooding in the West Avenue and Sunset Harbour neighborhoods. Did this make it more difficult for the Panel to identify concrete future co-benefits of adaptation?

Future research could also address whether unfamiliar adaptation actions, perceived by some community members as ambiguous or uncertain risks, can be reframed to be more appealing. It is well established that risky losses loom larger than
equivalent gains and certain outcomes are valued more than uncertain outcomes (Tversky and Kahneman, 1979) construed to have more concrete, immediate impacts, that can help motivate action. Reframing risks could be particularly impactful in issues of NIMBYism. At a community meeting in Miami Beach about raising streets, residents became concerned about the immediate loss of space for delivery trucks with the associated street realignment. This concern was addressed when a city representative noted that other neighborhoods could receive the proposed $20 million investment, reframing the adaptation investment as a potential immediate loss. Academic researchers could work with city staff to develop multiple problem risk frames as potential responses for community member opposition and analyze the impact on the support for a project and the success of the meeting. Additionally, projects like the Sunset Harbour improvements require multiple public meetings, creating opportunities to A/B test different risk frames. The impact of risk framing and support for adaptation could also be tested in an experimental setting, like a simulation, where the timeframe, uncertainty, and pathways in risk relationships can be carefully controlled.

5.2.2 Recommendation 2

Generate policy options by using dialogue to pursue consensus around risks. Engage the public in risk identification and communication to iteratively define risks and create shared descriptions of what is threatened at what timescale. Use these risks to set clear benchmarks for risk mitigation and measurable goals that encourage solutions which address short and long term risks. For example, in Miami Beach leaders connected the widely recognized threat of sea level rise to the city’s long term viability with a potential short term loss of confidence in the city’s real estate market and used that to
motivate immediate adaptation investments. Those definitions of risk arose through
dialogue on the Blue Ribbon Panel and in established forums like public meetings and
social media as stakeholders responded to the city’s adaptation efforts.

Developing clear, specific risks in dialogue with residents will help them identify
trade-offs between adaptation and inaction (Arvai, 2014). This way residents can see
where their money is being spent. They can be proud of the work the community is doing
and talk about it with each other. They can have confidence in local government
decisions and help maintain the political will to act. As sea levels continue to rise, the
new normal will be ongoing policy and infrastructure adjustment with periods of
accelerated change. Public works, including streets, pumps, sea walls, and even updated
building codes can be charismatic investments if residents can see the benefits to
community resilience. Having a physical reference point that helps residents understand
what resilience looks like will make it easier to maintain public support and public
optimism. Additionally, clearly communicating the consensus nature of the climate
science that underlies sea level rise risk can help residents avoid biases like myopia and
motivated reasoning or confirmation bias (Myers et al., 2015; van der Linden et al.,
2017), as was found in the immersive simulation in Chapter 2.

5.2.2.1 Future Research

An area ripe for study is the relationship between risk perception and
responsibility. Risk perceptions shape risk management decisions (Slovic et al., 1982).
Perceived control increases risk taking (Horswill and McKenna, 1999) and responsibility
can be understood as a form of control. Increased information availability and competing
narratives make it more difficult to assign responsibility for societal risks, including
climate change (Giddens, 1999). When the responsibility for implementing a specific adaptation response is linked to a risk it may influence how risks are constructed. When Miami Beach proposed raising the street around the Collin’s Park Garage, the County which owned the street opposed the action. The County failed to take responsibility for the future vulnerability of the unraised street. Perhaps this is because at the time the county Mayor was saying there was “no solution” for sea level rise (county budget meeting, September 17, 2015), and the county commissioner for Miami Beach believed that if the high sea level rise “projections are true then why should we do anything?” (personal conversation, September 23, 2015). These responses raise the question, does perceived responsibility for managing a risk decrease if there is no clear solution, e.g., over 6 feet of sea level rise in Miami Beach? If so, is it because the lack of control causes individuals to create distance from the problem of sea level rise and climate change? Alternatively, when a city like Miami Beach claims responsibility for a problem like sea level rise, how does that influence risk perception and the perceived distance of sea level rise impacts amongst decision makers and the general population?

Populations that are traditionally excluded from government decision making, like the poor and people of color, often lack representation in adaptation (Moser, 2016). It is possible that the reason social justice is not considered is because it is not identified within the risks associated with urgency to adapt and only comes into the adaptation conversation as a response to initial planning action. This would make integration or mainstreaming of justice issues into climate adaptation more difficult. Researchers working co-creatively with practitioners, facilitators, and community stakeholders could intervene to assertively integrate climate justice risks with other risks, e.g., neighborhood
flooding, to influence the solutions that are perceived as viable. They could then determine whether framing climate risks in terms of a city’s responsibility for vulnerable populations translates into more equitable adaptation investments.

In Miami, multiple organizations have raised concerns about climate justice including the Miami Climate Alliance, the CLEO institute, Catalyst Miami, the Kresge Foundation, and the Rockefeller Foundation. None of the three risks that informed the initial adaptation response in Miami Beach had an explicit focus on justice issues (see Chapter 3). The pathways connecting sea level rise as a threat to the city’s future viability focused on confidence in real estate investment and the response to flooding. Miami Beach has recently made equity a key component of its resilience planning as part of the Rockefeller Foundation’s 100 Resilient Cities network (Resilience Strategy Workshop, January 25, 2017). How this focus on equity shapes risk perceptions is academically interesting and important for local governments in their efforts to maintain support in vulnerable communities.

5.2.3 Recommendation 3

Focus on co-benefits. South Florida is culturally diverse. This diversity can cause conflict and distrust, but it is also a strength. The region is built on the ideas and experiences brought by immigrants from around the world, and it continually reinvents itself to attract new investments and residents. Deliberately articulating co-benefits of adaptation can reduce conflict and build trust. In the Netherlands, the focus on co-benefits has supported experimentation and consensus building present in the country’s two decade effort to respond to sea level rise through integrated water management (for example, see Chapter 4 or van Herk, Rijke, Zevenbergen, & Ashley, 2015). Adaptation,
including collaboration with the Dutch, will give South Florida a chance to continue evolving. Because of region’s porous bedrock, cultural innovations may be easier to apply than engineering solutions like dykes.

Cultural exchange with the Netherlands can build on existing collaborations. The South Florida Water Management District has a memorandum of agreement with The Netherlands\(^39\) and an ongoing collaboration with Deltares on flood and drought risk management (Welles, 2014). The Dutch Consulate in Miami regularly works with the Southeast Florida Climate Change Compact and other stakeholders to facilitate knowledge exchange through projects like the Dutch Dialogues and Resilient Redesign. Opportunities for technological and institutional exchange have been identified; however, cultural innovations remain underexplored as an area of exchange (Reuss, 2002). These collaborations focus primarily on technical knowledge sharing, but could be expanded to include cultural traits that increase resilience in each community, including the articulation of co-benefits.\(^40\)

### 5.2.3.1 Future Research

Barriers to adaptation have been extensively catalogued, but longitudinal research into the mechanisms behind barriers is needed (Biesbroek et al., 2014; Eisenack et al., 2014). Future research can investigate the critical period in which new stakeholders first engage the adaptation process, to understand how articulation of co-benefits impacts support for public investments in adaptation. In Chapter 3, the UBR framework –

\(^39\) Signed April 4, 2014 the memorandum of agreement commits to “shared information exchange” around water and flood management challenges.

\(^40\) For example, Dutch local governments are interested in how South Florida residents take personal responsibility for hurricane preparation. Recent experiments with a multi-layered approach to flood management have uncovered a dangerous lack of experience with disaster preparation and response among Dutch residents (Gersonius et al., 2016).
developed to observe the dynamic emergence of adaptation barriers – demonstrated that in a Miami Beach, a community with political leadership and financial support for adaptation, the barriers that arose were primarily institutional or caused by divergent risk perceptions among stakeholders. These appeared towards the end of the agenda setting phase and early in implementation, when new stakeholders entered the process, raising concerns about actions proposed by the City. In Miami Beach, articulating the benefits of adaptation actions to multiple stakeholder groups and to the city as a whole at different time periods was an important step in successfully responding to these challenges (Chapter 3). The UBR provides a mechanism for analyzing future case studies to test whether all types of barriers, including lack of financial resources, leadership, or climate information, emerge similarly in response to adaptation actions.

The UBR framework could also be used to compare past adaptation case studies. Cross city comparisons of adaptation implementation have cataloged specific measures (Broto and Bulkeley, 2013), analyzed the effectiveness of mainstreaming climate change into decision making (Uittenbroek et al., 2013), and looked at the responsibility of public and private actors (Mees, 2016). It has been argued that barriers must be addressed at multiple levels of governance (Juhola, 2016). Retrospective comparisons could look for patterns in the types of barriers that emerge and how they interact with variables, such as governance structure. Similarly, the UBR framework creates a means to analyze the role of facilitation, which was critical in the implementation of Rotterdam’s watersquares (see Chapter 4 and Recommendation 4 below), as a mechanism for the management of barriers.
Finally, Dutch academics have conducted some of the most in-depth research on policy entrepreneurship, including a recent survey of all 339 Dutch water policy entrepreneur working identified as working in local government (Brouwer and Huitema, 2017). This research could be expanded to include professional third-party facilitators. They could use this to identify differences in strategies, demographics, and educational backgrounds between traditional policy entrepreneurs and *neo-oliemannetjes*. Most policy entrepreneurs working in government are male engineers, whereas professional facilitators may have a more diverse background. Differences could also be identified between how public government policy entrepreneurs and *neo-oliemannetjes* in how stakeholders are selected, goals are articulated, and co-benefits are identified throughout the process. Additionally, Dutch researchers could look for the presence of *neo-oliemannetjes* in other sectors. If it is a cultural product, it seems likely that *neo-oliemannetjes* could exist in other areas such as energy and health care that have experienced technological and governance transitions (Loorbach and Rotmans, 2010).

5.2.4 Recommendation 4

Engage third-party facilitators, similar to the *neo-oliemannetje* introduced in Chapter 4, with the political savvy and technical skills to guide the design and implementation of adaptation projects in South Florida. Local governments should work with facilitators to engage neighboring jurisdictions in the process and support facilitator’s real and perceived independence by providing clear goals and timelines along with funding and political support for projects.

The purpose of third-party facilitators is to include necessary stakeholders and assist government staff in identifying risks, proposing solutions, and implementing
whatever decisions community leaders choose to pursue. Third-party facilitators build legitimacy and trust. Loyal to the problem rather than a single solution, they can articulate co-benefits and help communities avoid protracted arguments between stakeholders. They can guide a process that does not have a clear endpoint or an easily predetermined solution. Regional investment in adaptation facilitators, possibly coordinated by the Southeast Florida Climate Change Compact in partnership with universities, would build a core of professionals. This group could identify and replicate successful innovations, disseminate knowledge as it is created, and encourage collaboration between governments, agencies, and academics. Ideally, funding for projects would come from a state or regional authority. The South Florida Water Management District has been discussed as a possible source of unified regional funding (personal communication, February 9, 2017). It has regional taxing authority, experience collaborating with local governments, and, for example, must decide how to replace aging salinity barriers compromised by rising seas – a decision that will impact local water supply and flood management. Salinity barrier design and implementation provide an opportunity to experiment with third-party facilitation.

5.2.4.1 Future Research

Providing the information, tools, and facilitation to support adaptation decisions is critical for effective climate risk management and an area of ongoing research (Moss et al., 2014). Adaptation experiments in South Florida conducted in collaboration with academic researchers could provide an opportunity for field experiments to rigorously answer whether third-party facilitation increases perceived trust and legitimacy.
The Miami-Dade County Water and Sewer Department (WASD) began a 20 year $13.5 billion dollar capital improvement plan in 2015, which could provide a platform for academics and practitioners to collaborate on experimental facilitation. WASD has been a leader in the County’s climate adaptation efforts, has active partnerships with the regional academics, and is open to experimentation (WASD staff member interview, December 3, 2014). As a county wide utility, the capital improvements cross multiple jurisdictions and create opportunities for natural experiments, including measuring the impact of having a chief resilience officer on adaptation projects. Actual projects would have to follow WASD’s investment needs, but a hypothetical experiment would involve hiring internal and third-party facilitators to help plan and implement a set of neighborhood scale, stakeholder intensive projects like conversion from sceptic to sewer – a sea level rise adaptation strategy for areas with high groundwater. The success of these projects could be measured through surveys, resident participation, number of articulated co-benefits, and cost effectiveness of the project. Results could be compared across cities with a chief resilience officer like Miami, cities without like South Miami, and unincorporated county neighborhoods.

Experimental collaboration between academics and stakeholders could be also be appealing to external funders, i.e., federal agencies and private foundations that support adaptation, as an opportunity to increase the broader impact of ongoing investments in scientific research. Large team science projects are a potential source of external funding for third-party facilitation. Stakeholder engagement in these projects is often assigned to academic social scientists whose primary incentive is publication. This can create real and perceived lack of interest in addressing the practical problem of implementing
solutions. A major goal of federal science funding is to have broader impacts on communities and practice. This is especially important in climate change, where the science can advance quickly and disseminating that knowledge is difficult. Networks like the National Oceanic and Atmospheric Administrations’ Regional Integrated Science and Assessments (RISAs) have increased the use of climate information in decision making but significant challenges remain (Kirchhoff, 2013). Could this be further accelerated through targeted facilitation of specific stakeholder interactions?

The National Science Foundation and other granting organizations that support large, interdisciplinary water and climate projects could experiment with the use of professional policy entrepreneurs. Large interdisciplinary grants like Sustainability Research Networks which “bring together multidisciplinary teams of researchers, educators, managers, policymakers and other stakeholders to conduct collaborative research that addresses fundamental challenges in sustainability” have ambitious goals to develop useable science that can be implemented by stakeholders. These team science efforts struggle to align incentives across disciplines and universities as well as between academics and practitioners (Lang et al., 2012; Lynch et al., 2015). A facilitator hired by the team science project for a specified set of time to address a specific policy problem could fulfill the neo-oliemanntje role. Guiding a collaboration between academics and stakeholders they could help articulate potential co-benefits and shape the team’s research to support those benefits.

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42 https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503645
For example, the simulation study in Chapter 2 was conducted as part of a $5 million five-year Water, Sustainability and Climate project funded by the National Science Foundation to create a hydro-economic model of the Everglades watershed. The motivation for the project was to help decision makers in South Florida make politically contentious tradeoffs between water quality, flood protection, and supply as the climate changes. A team of over 30 academics partnered with stakeholders from local governments and agencies from the start of the project, nevertheless the project has not fully achieved its goal of informing policy. It is possible that an independent third-party facilitator trusted by academics and stakeholders could have increased the project’s impact by aligning expectations and strategizing how to connect outputs with decision makers.

5.3 Conclusions

Reducing the threat climate change and sea level rise pose to people, property, and ecosystems in South Florida is an exciting and worthy research challenge. The work presented in this dissertation has the potential to be a positive force, if it can be meaningfully integrated into the regional response to climate change. The determinants of adaptation may be more cultural than physical (Adger et al., 2009a), and after five years immersed in South Florida one conclusion is clear: collaboration is essential.

The necessity of collaboration is not a new idea. Climate change adaptation is far too complex for individuals or even individual communities to address alone. Co-production of knowledge (Lemos et al., 2012) and collaborative decision making (Moss et al., 2014) are established goals in climate adaptation. However, fostering collaboration is particularly important in Miami, where a culture that celebrates individualism, you
only live one (YOLO) attitudes, and “what’s in it for me?” makes collaboration a constant challenge. Speaking about the intersection of sustainability, public health, and affordable housing – problems made more difficult by climate change – one county commissioner said that in Miami collaboration is the greatest obstacle (public meeting, January 30, 2015).

Acknowledging that collaboration will be a challenge in South Florida, adaptation to sea level rise can be designed to create opportunities for stakeholders to productively enter into the process. Not everyone can be involved in addressing problems from the start, but by anticipating collaboration, the collective response to climate change can be truly adaptive, creating space for new actors and parties to engage and improve outcomes. Climate change will create new opportunities for collaboration between governments, with academic researchers, and within and across communities. At its core collaboration is the exchange of ideas and culture in pursuit of a shared goal. More than any specific solution, mechanism, or governance approach cultural exchange increases the capacity to respond. That is what is needed for South Florida to grow and adapt in response to the multifaceted challenge of climate change.
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Appendix A

Table A.1
Mean and standard deviation of responses to measures recorded in each time period:

<table>
<thead>
<tr>
<th>Measure</th>
<th>2016</th>
<th></th>
<th>2030</th>
<th></th>
<th>2050</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Move Intention</td>
<td>4.07</td>
<td>1.90</td>
<td>4.69</td>
<td>1.88</td>
<td>5.30</td>
<td>1.92</td>
</tr>
<tr>
<td>Worry</td>
<td>4.75</td>
<td>1.74</td>
<td>5.06</td>
<td>1.71</td>
<td>5.42</td>
<td>1.76</td>
</tr>
<tr>
<td>Vote (yes)</td>
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<td>--</td>
<td>0.76</td>
<td>--</td>
<td>0.76</td>
<td>--</td>
</tr>
<tr>
<td>Sources of worry</td>
<td>3.7</td>
<td>2.3</td>
<td>4.2</td>
<td>2.5</td>
<td>4.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Protective actions</td>
<td>1.6</td>
<td>1.0</td>
<td>1.7</td>
<td>1.1</td>
<td>2.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table A.2
Mean and standard deviation of intention to move and worry as well as proportion of participants voting yes on the bond measure by each manipulation condition (high vs low sea level rise in 2030, social norms in the form of vote passage or failure in 2016, framing as economic or environmental in 2050). 2016 and portions of 2030 have no results because the manipulation had not been introduced before choices were made:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th>2016</th>
<th></th>
<th>2030</th>
<th></th>
<th>2050</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
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<tr>
<td>Move Intention</td>
<td>Sea Level 2030</td>
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<td>--</td>
<td>--</td>
<td>4.85</td>
<td>1.8</td>
<td>5.4</td>
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<tr>
<td></td>
<td></td>
<td>Low</td>
<td>--</td>
<td>--</td>
<td>4.53</td>
<td>1.9</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vote 2016</td>
<td>Pass</td>
<td>--</td>
<td>4.68</td>
<td>1.9</td>
<td>5.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fail</td>
<td>--</td>
<td>4.70</td>
<td>1.9</td>
<td>5.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Framing 2030</td>
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<td>--</td>
<td>--</td>
<td>5.39</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Environmental</td>
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<td>--</td>
<td>--</td>
<td>5.20</td>
</tr>
<tr>
<td>Worry</td>
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<td>--</td>
<td>5.22</td>
<td>1.8</td>
<td>5.45</td>
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<td>4.90</td>
<td>1.7</td>
<td>5.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vote 2016</td>
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<td>--</td>
<td>4.99</td>
<td>1.8</td>
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<td></td>
<td></td>
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<td>1.6</td>
<td>5.38</td>
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<tr>
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<td>Framing 2030</td>
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<td>--</td>
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<td>5.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Environmental</td>
<td>--</td>
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<td>--</td>
<td>5.38</td>
</tr>
<tr>
<td>Vote</td>
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<td>--</td>
<td>0.73</td>
<td>--</td>
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</tr>
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<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Pass</td>
<td>--</td>
<td>0.76</td>
<td>--</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fail</td>
<td>--</td>
<td>0.76</td>
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<td>0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Framing 2030</td>
<td>Economic</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Environmental</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.76</td>
</tr>
</tbody>
</table>
Table A.3
Percentage of participants answering yes to “Which of the following actions would you seriously consider taking? (approximate prices)” to reduce the effect of sea level rise on your home and property in each time period:

<table>
<thead>
<tr>
<th>Protective actions</th>
<th>2016</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve drainage ($5000)</td>
<td>51%</td>
<td>54%</td>
<td>59%</td>
</tr>
<tr>
<td>Elevate the house ($20,000 down + loans or grants)</td>
<td>16%</td>
<td>22%</td>
<td>31%</td>
</tr>
<tr>
<td>Flood proof the ground floor ($1500)</td>
<td>45%</td>
<td>48%</td>
<td>50%</td>
</tr>
<tr>
<td>Buy flood insurance ($2500/year)</td>
<td>49%</td>
<td>52%</td>
<td>57%</td>
</tr>
<tr>
<td>Rent elevated parking ($100/month)</td>
<td>16%</td>
<td>16%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Table A.4
Percentage of participants indicating that an item is a “major source of concern” in each time period:

<table>
<thead>
<tr>
<th>Source of worry</th>
<th>2016</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental damage</td>
<td>46%</td>
<td>53%</td>
<td>57%</td>
</tr>
<tr>
<td>Insurance prices</td>
<td>59%</td>
<td>61%</td>
<td>64%</td>
</tr>
<tr>
<td>Personal property damage/flood proofing</td>
<td>65%</td>
<td>65%</td>
<td>67%</td>
</tr>
<tr>
<td>Real estate values</td>
<td>46%</td>
<td>48%</td>
<td>56%</td>
</tr>
<tr>
<td>Water supply/saltwater intrusion</td>
<td>51%</td>
<td>54%</td>
<td>57%</td>
</tr>
<tr>
<td>Storm surge</td>
<td>46%</td>
<td>54%</td>
<td>61%</td>
</tr>
<tr>
<td>Tax increases</td>
<td>47%</td>
<td>49%</td>
<td>57%</td>
</tr>
<tr>
<td>Seasonal tidal flooding</td>
<td>38%</td>
<td>52%</td>
<td>57%</td>
</tr>
</tbody>
</table>

Table A.5
Participant answers to the question, “How soon do you think conditions would be such that you would leave?” in 2016, 2030, and 2050:

<table>
<thead>
<tr>
<th>How soon would you leave?</th>
<th>2016</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soon – less than 5 years</td>
<td>59</td>
<td>87</td>
<td>138</td>
</tr>
<tr>
<td>6 - 10 years</td>
<td>103</td>
<td>109</td>
<td>73</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>114</td>
<td>87</td>
<td>73</td>
</tr>
<tr>
<td>Not sure</td>
<td>59</td>
<td>52</td>
<td>51</td>
</tr>
</tbody>
</table>
Table A.6
Mean and standard deviation of intention to move and worry as well as proportion of participants voting yes on the bond measure by individual differences within groups for each time period:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Group</th>
<th>Subgroup</th>
<th>2016 Mean</th>
<th>2016 SD</th>
<th>2030 Mean</th>
<th>2030 SD</th>
<th>2050 Mean</th>
<th>2050 SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move Intention</td>
<td>Income</td>
<td>Lower</td>
<td>4.1</td>
<td>1.8</td>
<td>4.9</td>
<td>1.8</td>
<td>5.4</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>3.9</td>
<td>1.9</td>
<td>3.9</td>
<td>1.9</td>
<td>5.0</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>4.4</td>
<td>2.0</td>
<td>4.9</td>
<td>1.9</td>
<td>5.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Age</td>
<td>Under 45</td>
<td></td>
<td>4.5</td>
<td>1.9</td>
<td>5</td>
<td>1.8</td>
<td>5.5</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>45+</td>
<td></td>
<td>3.7</td>
<td>1.8</td>
<td>4.5</td>
<td>1.9</td>
<td>5.1</td>
<td>2</td>
</tr>
<tr>
<td>Political</td>
<td>Conservative</td>
<td></td>
<td>3.7</td>
<td>1.7</td>
<td>4.8</td>
<td>2</td>
<td>5.2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Centrist</td>
<td></td>
<td>4.2</td>
<td>2.1</td>
<td>4.3</td>
<td>1.8</td>
<td>5.1</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Liberal</td>
<td></td>
<td>4.5</td>
<td>1.8</td>
<td>5.1</td>
<td>1.7</td>
<td>5.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Worry</td>
<td>Income</td>
<td>Lower</td>
<td>4.8</td>
<td>1.7</td>
<td>5.3</td>
<td>1.6</td>
<td>5.5</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>4.4</td>
<td>1.7</td>
<td>4.7</td>
<td>1.7</td>
<td>5.2</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>5.1</td>
<td>1.7</td>
<td>5.2</td>
<td>1.7</td>
<td>5.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Age</td>
<td>Under 45</td>
<td></td>
<td>4.9</td>
<td>1.8</td>
<td>5.3</td>
<td>1.7</td>
<td>5.6</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>45+</td>
<td></td>
<td>4.6</td>
<td>1.7</td>
<td>4.8</td>
<td>1.7</td>
<td>5.3</td>
<td>1.8</td>
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<tr>
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<td>4.7</td>
<td>1.9</td>
<td>5</td>
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<td>5.3</td>
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<tr>
<td></td>
<td>Centrist</td>
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<td>4.5</td>
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<td>4.9</td>
<td>1.5</td>
<td>5.1</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Liberal</td>
<td></td>
<td>5.1</td>
<td>1.5</td>
<td>5.3</td>
<td>1.7</td>
<td>6</td>
<td>1.4</td>
</tr>
<tr>
<td>Vote</td>
<td>Income</td>
<td>Lower</td>
<td>0.74</td>
<td>--</td>
<td>0.76</td>
<td>--</td>
<td>0.76</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>0.71</td>
<td>--</td>
<td>0.71</td>
<td>--</td>
<td>0.73</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>0.84</td>
<td>--</td>
<td>0.83</td>
<td>--</td>
<td>0.79</td>
<td>--</td>
</tr>
<tr>
<td>Age</td>
<td>Under 45</td>
<td></td>
<td>0.79</td>
<td>--</td>
<td>0.78</td>
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<td>0.78</td>
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</tr>
<tr>
<td></td>
<td>45+</td>
<td></td>
<td>0.73</td>
<td>--</td>
<td>0.74</td>
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<td>0.74</td>
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<tr>
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<td>Conservative</td>
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<td>0.77</td>
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<td>0.83</td>
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<td>0.75</td>
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<td>0.69</td>
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<td>0.78</td>
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<tr>
<td></td>
<td>Liberal</td>
<td></td>
<td>0.79</td>
<td>--</td>
<td>0.75</td>
<td>--</td>
<td>0.76</td>
<td>--</td>
</tr>
<tr>
<td>Preventive actions</td>
<td>Income</td>
<td>Lower</td>
<td>1.6</td>
<td>1.0</td>
<td>1.7</td>
<td>1.0</td>
<td>1.9</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>1.6</td>
<td>1.0</td>
<td>1.8</td>
<td>1.2</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>1.8</td>
<td>1.1</td>
<td>1.8</td>
<td>1.1</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>Age</td>
<td>Under 45</td>
<td></td>
<td>1.7</td>
<td>1.1</td>
<td>1.8</td>
<td>1.1</td>
<td>2</td>
<td>1.4</td>
</tr>
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<td>1.0</td>
<td>1.7</td>
<td>1.1</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>Political</td>
<td>Conservative</td>
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<td>1.6</td>
<td>1.0</td>
<td>1.9</td>
<td>1.2</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Centrist</td>
<td></td>
<td>1.6</td>
<td>0.9</td>
<td>1.7</td>
<td>1.0</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Liberal</td>
<td></td>
<td>1.8</td>
<td>1.1</td>
<td>1.8</td>
<td>1.2</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>Sources of concern</td>
<td>Income</td>
<td>Lower</td>
<td>4</td>
<td>2.3</td>
<td>4.5</td>
<td>2.5</td>
<td>4.7</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle</td>
<td>3.5</td>
<td>2.2</td>
<td>3.8</td>
<td>2.3</td>
<td>4.3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>3.8</td>
<td>2.4</td>
<td>4.3</td>
<td>2.6</td>
<td>4.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Table A.7
Responses to pre-survey knowledge and worry about sea level rise, collected post simulation:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-survey knowledge of SLR</td>
<td>4.1</td>
<td>1.74</td>
<td>339</td>
</tr>
<tr>
<td>Pre-survey worry about SLR</td>
<td>3.84</td>
<td>1.90</td>
<td>339</td>
</tr>
</tbody>
</table>

Table A.8
Demographics, collected post simulation:

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Group</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Under 45</td>
<td>163</td>
</tr>
<tr>
<td></td>
<td>Over 45</td>
<td>185</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>206</td>
</tr>
<tr>
<td></td>
<td>Prefer not to answer</td>
<td>1</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Yes</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>225</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Asian</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Black/African American</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Native American/Pacific Islander</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>274</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Asian &amp; Black</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Black &amp; White</td>
<td>1</td>
</tr>
<tr>
<td>Education</td>
<td>Some high school</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>High school</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Some college</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>College graduate</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>Some post-graduate studies</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Masters or Ph.D.</td>
<td>46</td>
</tr>
<tr>
<td>Income</td>
<td>&lt; $45,000 (lower)</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>$45,001 - $80,000 (middle)</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>&gt; $80,000 (upper)</td>
<td>92</td>
</tr>
<tr>
<td>Political affiliation</td>
<td>Liberal</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Centrist</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Conservative</td>
<td>90</td>
</tr>
<tr>
<td>Flood insurance</td>
<td>Yes</td>
<td>145</td>
</tr>
<tr>
<td>No</td>
<td>178</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Do not know</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Live in a flood zone</td>
<td>Yes</td>
<td>67</td>
</tr>
<tr>
<td>No</td>
<td>182</td>
<td></td>
</tr>
<tr>
<td>Do not know</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

Table A.9
ANOVA of differences in mean move intention and worry from 2016 vs 2030 and 2030 vs 2050.

<table>
<thead>
<tr>
<th>DV</th>
<th>IV</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move intention</td>
<td>Year (2016 vs 2030) Residuals</td>
<td>1</td>
<td>674</td>
<td>2399</td>
<td>65.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Move intention</td>
<td>Year (2030 vs 2050) Residuals</td>
<td>1</td>
<td>663</td>
<td>2389</td>
<td>62</td>
<td>3.6</td>
</tr>
<tr>
<td>Worry</td>
<td>Year (2016 vs 2030) Residuals</td>
<td>1</td>
<td>643</td>
<td>1910</td>
<td>15.11</td>
<td>2.97</td>
</tr>
<tr>
<td>Worry</td>
<td>Year (2030 vs 2050) Residuals</td>
<td>1</td>
<td>631</td>
<td>1905</td>
<td>20.57</td>
<td>3.02</td>
</tr>
</tbody>
</table>

Table A.10
ANOVA tables of intention to move, worry, and vote by manipulated conditions (high vs low sea level rise, social norms in the form of vote passage or failure, framing as economic or environmental).

<table>
<thead>
<tr>
<th>DV</th>
<th>IV</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move intention 2030</td>
<td>Sea Level Rise Residuals</td>
<td>1</td>
<td>332</td>
<td>1163</td>
<td>8.73</td>
<td>3.5</td>
</tr>
<tr>
<td>Move intention 2030</td>
<td>Vote pass/fail Residuals</td>
<td>1</td>
<td>332</td>
<td>1172</td>
<td>0.04</td>
<td>3.53</td>
</tr>
<tr>
<td>Move intention 2050</td>
<td>Framing Residuals</td>
<td>1</td>
<td>329</td>
<td>1215</td>
<td>2.86</td>
<td>3.69</td>
</tr>
<tr>
<td>Worry 2030</td>
<td>Sea Level Rise Residuals</td>
<td>1</td>
<td>319</td>
<td>929</td>
<td>8.48</td>
<td>2.91</td>
</tr>
<tr>
<td>Worry 2030</td>
<td>Vote pass/fail Residuals</td>
<td>1</td>
<td>319</td>
<td>936</td>
<td>1.49</td>
<td>2.93</td>
</tr>
<tr>
<td>Worry 2050</td>
<td>Framing Residuals</td>
<td>1</td>
<td>310</td>
<td>963</td>
<td>4.86</td>
<td>3.11</td>
</tr>
<tr>
<td>Vote 2030</td>
<td>Sea Level Rise Residuals</td>
<td>1</td>
<td>340</td>
<td>62</td>
<td>0.24</td>
<td>0.18</td>
</tr>
<tr>
<td>Vote 2030</td>
<td>Vote pass/fail Residuals</td>
<td>1</td>
<td>340</td>
<td>62</td>
<td>0.001</td>
<td>0.18</td>
</tr>
<tr>
<td>Vote 2050</td>
<td>Framing Residuals</td>
<td>1</td>
<td>339</td>
<td>62</td>
<td>0.004</td>
<td>0.18</td>
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</table>
Table A.11
ANOVA tables of move intention, worry, and vote by differences between groups

<table>
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<tr>
<th>DV</th>
<th>Group</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move Intention</td>
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