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KEEPING CASTLES OUT OF THE SAND: CLIMATE CHANGE ADAPTATION IN NORTHEAST COASTAL COMMUNITIES

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ABSTRACT OF THE DISSERTATION

Keeping Castles Out of the Sand:

Climate change adaptation in northeast coastal communities

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Unprecedented losses from natural disasters in recent years have awakened coastal communities to the increasing risks from climate change. Many are choosing to adapt on their own, yet many others may not know where to begin. To address this gap in knowledge and help disseminate information on adaptation strategies, a mixed-methods study was undertaken to inventory and assess the performance of locally-driven climate adaptation strategies in 34 coastal communities in the Northeast US from Maine to Virginia.

Findings revealed that communities are implementing climate change adaptation by using low-cost tools such as comprehensive planning, land use regulations, and building codes far more frequently than using conventional solutions, such as gray infrastructure. Communities are motivated to take action to protect themselves from the hazards of climate change, protect the environment, and respond to constituent demands for action, and less likely to be motivated by elected officials and external incentives such as funding availability or the FEMA Community Rating System (CRS).

The Intergovernmental Panel on Climate Change identified three types of strategies to adapt to sea level rise: accommodation, protection, and retreat.¹ A key finding is that many adaptations, notably most planning activities, do not fit within these three, and hence two new strategies were defined: prevention and procedural. Prevention actions, which preempt development in hazardous locations, such as through land conservation, are important but infrequently utilized. Procedural actions, which generate information or amend processes, plans, and laws, are very commonly adopted. The IPCC is not alone in overlooking these strategies, as data from Superstorm Sandy recovery plans in New York State suggests. However, such strategies are essential because they effect change in a way that makes adaptation standard or routine, result in less community disruption, and require little funding. Innovative action found in every state in the region, and in diverse municipalities with varying demographic and geographic characteristics, demonstrate that it is within communities' power and interest to adapt to

¹ Intergovernmental Panel on Climate Change (1990). Report of the Coastal Zone Management Subgroup, Response Strategies Working Group. Ministry of Transport, Public Works and Water Management: The Hague, Netherlands.

climate change, and they can do so using low-cost tools that support long-term resilience instead of expensive and fallible infrastructure to band-aid vulnerabilities.

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CHAPTER 1 - INTRODUCTION

1.1. THE CHALLENGE OF ADAPTING TO CLIMATE CHANGE

At first blush, it might appear that the seeming increase in the intensity and frequency of weather-related natural disasters such as floods, hurricanes, heat waves, and extratropical cyclones could be attributable to what is known in psychology as recency effects, that is, the tendency of humans to recall most clearly the events of the recent past.² The data, however, suggest otherwise. According to the National Oceanic and Atmospheric Association (NOAA), 2015 was in fact the planet's warmest year since recordkeeping began, featuring ten months with record highs for their respective months, and the December 2015 combined global land and ocean surface temperature was the warmest for any month in history.³ Average temperatures were 0.9°C (1.62°F) above the 20th century mean, surpassing the previous record, set in 2014, by 0.16°C (0.29°F). Land surface temperatures were 1.33°C (2.39°F) above the 20th century mean, the highest of all years on record, and breaking the record by the largest margin in history.

² Sabine M. Marx, Elke U. Weber, Benjamin S. Orlove, Anthony Leiserowitz, David H. Krantz, Carla Roncoli, & Jennifer Phillips, "Communication and mental processes: Experiential and analytic processing of uncertain climate information," *Global Environmental Change*, 17, no. 1 (2007): 47-58,

http://www.sciencedirect.com/science/article/pii/S0959378006000847

³ National Oceanic and Atmospheric Administration (NOAA), National Climactic Data Center, "Global Summary Information," accessed December, 2015, http://www.ncdc.noaa.gov/sotc/



Figure 1: Time series of the annual frequency and damages of US billion dollar disasters (1980-2011) fitted by Poisson regression. Source: Smith, Adam B., and Richard W. Katz. "US billion-dollar weather and climate disasters: data sources, trends, accuracy and biases." Natural Hazards 67, no. 2 (2013): 387-410.

While the data unequivocally indicate an increasingly warm planet, recent years have also seen increasing damage from weather-related natural disasters.

In the U.S. alone, the total cost of billion dollar disasters since 1980 is greater than \$1 trillion, and the pattern is toward increasing losses.⁴ There were 188 weather and climate disasters with greater than than \$1 billion in losses each (including CPI adjustment to 2015).⁵ Over the 25 year period 1980-2015 the average number of CPI-adjusted events was 5.2, and it has risen to 10.8 for the years 2011-2015.⁶ In 2015, there were 10 climate related disasters causing more than \$1 billion in damages in the U.S.⁷

⁴ NOAA, National Center for Environmental Information. "Billion-Dollar Weather and Climate Disasters: Overview." n.d., https://www.ncdc.noaa.gov/billions/ ⁵ Ibid.

⁶ Ibid.

⁷ NOAA, National Center for Environmental Information. "2015 in Context." https://www.ncdc.noaa.gov/billions/overview

Globally, 2015 featured 29 billion-dollar disasters, the 4th most on record.⁸ Although the average for 2015 was 30% below the 15-year average, 9 nations had their most expensive disasters in history, including Indonesia, Romania, South Africa, Ethiopia, Malawi, Vanatu, Chile, Dominica and Botswana. 2014 was a relatively quiet year with only 25 billion-dollar disasters, also slightly below the past average.⁹ 2013 was a record year for billion-dollar disasters. Six countries set records for the most costly disasters in their history, including Super Typhoon Haiyan in the Phillipines, which was one of the most destructive tropical cyclones in history, killing over 8,000 people and causing \$5.8 billion in damage.¹⁰ Germany, Austria, the Czech Republic, New Zealand and Cambodia, all incurred major losses from flooding. In 2012, there were 26 such billion-dollar loss events, including Superstorm Sandy, the second most expensive disaster in U.S. history.¹¹ The recent extremes are part of a longterm pattern of increasing losses. As reported by Leaning and Guha-Sapir in Figure 2, the annual number of disasters around the world increased from under 50 in the 1950s to over 350 in the most recent decade, with a corresponding increase in economic damage from around \$25 billion in the

⁸ Jeff Masters, "Earth's 29 Billion Dollar Weather Disasters of 2015: 4th Most on Record." *WunderBlog.* (Jan. 19, 2016). https://www.wunderground.com/blog/JeffMasters/earths-29billiondollar-weather-disasters-of-2015-4th-most-on-recor

⁹ Jeff Masters, "The 25 Billion-Dollar Weather Disasters of 2014." *WunderBlog.* (Jan. 13, 2015). https://www.wunderground.com/blog/JeffMasters/the-25-billiondollar-weather-disasters-of-2014

¹⁰ Jeff Masters, "Earth's Record 41 Billion-Dolar Weather Disasters of 2013." (Jan. 17, 2014). WunderBlog. https://www.wunderground.com/blog/JeffMasters/earths-record-41billiondollar-weather-disasters-of-2013

¹¹ Jeff Masters, "Top Ten Global Weather Events of 2012." (Jan. 11, 2013). *WunderBlog.* https://www.wunderground.com/blog/JeffMasters/top-ten-global-weather-events-of-2012



Figure 2 - Frequency, types, and economic damage of natural disasters around the world (1950-2012). Source: Leaning, Jennifer, and Debarati Guha-Sapir. "Natural disasters, armed conflict, and public health." New England journal of medicine 369, 19 (2013): 1836-1842.

1950s to over \$250 billion in the 2000s (in 2012 dollars).¹² The authors state that "although better communications may play a role in the trend, the growth is mainly in climate-related events, accounting for nearly 80% of the increase, whereas trends in geophysical events have remained stable."¹³ The U.S. has had a similar pattern, as reported by Smith and Katz. They found an increasing trend in annual aggregate losses (including physical damage to buildings, time element losses, vehicles, infrastructure, and agricultural assets) is "attributable to a statistically significant increasing trend of about 5% per year in the frequency of billion-dollar disasters."¹⁴

¹² Jennifer Leaning and Deberati Guha-Sapir, "Natural disasters, armed conflict, and public health," *New England Journal of Medicine*, 369, no.19 (2013): 1836-1842. doi: 10.1056/NEJMra1109877.

¹³ Ibid., 1836.

¹⁴ Adam B. Smith and Richard W. Katz, "US billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases," *Natural Hazards* 67, no. 2(2013): 1-26, 2.

The names of tropical cyclones Irene, Floyd, Katrina and Ike may have forever changed the way Americans view nature. And in October 2012, Hurricane Sandy¹⁵ came out of the Caribbean, morphed from a minimal hurricane into a post-tropical cyclone, and slammed in to the Northeast coast, causing unprecedented damage, despite the fact that it was not even a Category One storm. Sandy's massive destruction, as well as the impacts from other recent storms, have done much to shift public discussion about sea level rise and climate change from the theoretical to the practical. Like Katrina in the Gulf Coast, the storm galvanized public discourse about the impact of climate change on coastal communities. And, although we know that "no single extreme event is evidence of climate change...taken together, unusual weather has given a sense the climate is changing..."¹⁶

New York Governor Andrew Cuomo was widely quoted after the storm: "Anyone who says there is not a change in weather patterns is denying reality."¹⁷ It was followed by Mayor Michael Bloomberg's own unequivocal statement:

While the increase in extreme weather we have experienced in New York City may or may not be the result of climate change, the risk that

¹⁶ Anthony D. Del Genio, "Will a warmer world be stormier?" *Earthzine*. April 1, 2011.
accessed March 29, 2016, <u>http://earthzine.org/2011/04/16/will-a-warmer-world-be-stormier/</u>
¹⁷ Raymond Hernandez, "Bloomberg backs Obama, citing fallout from storm," *The New York Times*, November 1, 2012, accessed March 29, 2016,

 $^{^{15}}$ Although technically the storm was post-tropical at landfall, for consistency I will refer to it as Hurricane Sandy throughout this paper.

http://www.nytimes.com/2012/11/02/nyregion/bloomberg-endorses-obama-saying-hurricanesandy-affected-decision.html

it might be - given this week's devastation - should compel all elected leaders to take immediate action. 18

Thus adaptation to expected impacts of climate change has been increasingly publicly recognized as essential. The Intergovernmental Panel on Climate Change defines adaptation as "adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." ¹⁹ Adaptation to climate change typically seems a long-range concern, but, as Titus presciently observed a generation ago:

Although sea level is not expected to rise rapidly until after 2000...communities may have to consider its consequences much sooner. After the next major storm, in particular, homeowners whose properties are destroyed will decide whether and how to rebuild; and local governments will decide whether or not to let all of them rebuild, and which options are appropriate to address the storm-induced erosion.²⁰

The aftermath of Superstorm Sandy's landfall in October 2012 confirmed Titus' prediction. However, the question remains of how communities can adapt. Smith, Ragland and Pitts, outlining an assessment process for anticipatory adaptation measures, suggest priority for adaptations that address

http://opinionator.blogs.nytimes.com/2012/11/07/a-change-in-the-weather-on-wall-street/ ¹⁹ James J. McCarthy, Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, Kasey S. White (Eds.), *Climate change 2001: Impacts, adaptation, and vulnerability: contribution of working group to the third assessment report of the Intergovernmental Panel on Climate Change.* (Cambridge: Cambridge University Press, 2001), accessed March 29, 2016, http://www.preventionweb.net/files/8387_wg2TA Rfrontmatter1.pdf

¹⁸ Tina Rosenberg, "A change in the weather on Wall Street," *The New York Times*, November 7, 2012, accessed March 29, 2016,

²⁰ James G. Titus, "Planning for sea level rise before and after a coastal disaster," in *Greenhouse effect and sea level rise: a challenge for this generation*, eds. M. C. Barth & J. G. Titus, (New York: Van Nostrand Reinhold Company, 1984), 254-268, at p. 254.

irreversible or catastrophic consequences of climate change or that demand long-term decisions.²¹ They add that adaptation measures should address "targets of opportunity," such as decisions on long-term planning and land development. Local planning and zoning have impacts that often last centuries and must accommodate changing conditions far into the future. Addressing climate change in local planning decisions is both critical and opportune.

As the Second National Assessment on Natural and Related Technological Hazards states, "No single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land-use management." ²² The National Oceanic and Atmospheric Administration, reporting on the Second National Assessment, added, "the same is likely to hold true for climate change adaptation as well."²³

In many ways, climate change presents a challenge for urban planning that may be, much like smart growth was described by Burchell, Listokin and

²¹ J. B. Smith, S. E. Ragland, and G. J. Pitts, "A process for evaluating anticipatory adaptation measures for climate change," *Water, Air, and Soil Pollution*, 92, no. 1 (Nov. 1996): 229-238.

²² D. S. Mileti, Disasters by Design: A reassessment of natural hazards in the United States (Boulder, Colorado: National Academies Press, 1999), 155-156.

²³ National Oceanic and Atmospheric Administration (NOAA), *Adapting to climate change: A planning guide for state coastal managers* (Silver Spring, MD: NOAA Office of Ocean and Coastal Resource Management, 2010), 49.

Galley, another "Ghost of Urban Policy Past" rather than a bold new horizon.²⁴ That is because traditional land use tools may be the best means communities have to adapt to climate change. Seemingly prosaic regulations such as setback provisions, shoreline protection provisions, height limits, buffers, dune protection ordinances, and transfer or purchase of development rights are all plausible avenues to advance adaptation. Yet many communities do not have the tools or knowledge to best prepare them. Some may simply plan reactively in the wake of a disaster, without adequate forethought regarding their decisions' long-term implications.

This thesis aims to help coastal communities plan for a sustainable and resilient future. It explores types of climate change adaptation being implemented in the North Atlantic region, and analyzes their costs, effectiveness, and transferability. The urgency and relevance of this work has risen enormously since Superstorm Sandy.

The extant literature suggests effective climate planning will be challenging to implement. Wheeler finds that much of the action in climate change policy is

²⁴ Robert W. Burchell, David Listokin, and Catherine C. Galley, "Smart growth: More than a ghost of urban policy, less than a bold new horizon," *Housing Policy Debate* 11, no. 4 (2000): 812-889. Accessed March 30, 2016, doi: 10.1080/10511482.2000.9521390

more hype than substance, both at the state and local level.²⁵ He cites lack of adequate goals, strong actions, and political and institutional muscle necessary to truly tackle climate change mitigation or adaptation. Donner and Webber find that uncertainties in climate change predictions can lead to a focus on short-term interests and a reactive response to extreme events, while with long-term adaptation strategies are ignored. ²⁶ Discussing studies on earthquake hazards, Olshansky and Kartez write:

...political and institutional roadblocks to hazard mitigation are formidable. Studies...have suggested there is no public constituency, costs are immediate and benefits uncertain, benefits may not occur during the tenure of current elected officials, public safety is not visible, and other public issues are more immediate.²⁷

Relying on all these findings, one would be surprised to find effective climate change action plentiful, especially at the local level.

This study seeks a more nuanced understanding of which climate adaptations communities implemented and consider effective. Moreover, it improves understanding of strengths and limitations of the current institutional arrangements and suggests a path forward. In particular, this paper makes a

²⁵ Steven M. Wheeler, "State and municipal climate change plans: The first generation," *Journal of the American Planning Association* 74, no. 4 (2008): 481-496. doi: 10.1080/01944360802377973.

²⁶ S. D. Donner Webber, "Obstacles to Climate Change Adaptation Decisions: A Case Study of Sea-Level Rise and Coastal Protection Measures in Kiribati," *Sustainability Science* 9, no. 3 (2014): 331–45, doi:10.1007/s11625-014-0242-z.

²⁷ Robert Olshansky and Jack D. Kartez, "Managing land use to build resilience," in *Cooperating with nature, confronting natural hazards with land-use planning for sustainable communities*, ed. Raymond Burby (Washington, DC: Joseph Henry Press, 1998), 167-202, 181.

number of contributions to the literature on local adaptation to climate change in coastal communities. It presents an inventory and analysis of adaptive practices in 34 localities in the ten Atlantic Seaboard states from Virginia to Maine; measures and compares their relative costs, efficacy and transferability; improves understanding of their motives; assesses their legal implications; summarizes current state laws; and evaluates proposed post-Sandy recovery projects. Finally, it presents future implications.

1.2. OBJECTIVES AND RESEARCH QUESTIONS

This dissertation seeks to answer questions about how and why climate change adaptation planning is being implemented in northeast coastal communities. The initial objective of this project was to develop content for regional NOAA outreach efforts by encouraging a peer-to-peer network among community leaders to share climate change adaptation best practices. The project identified and collated low-cost municipal-scale coastal management actions attractive to communities. This dissertation furthers the NOAA project by categorizing adaptations on multiple dimensions, including frequency and type, and providing detailed information about project costs, effectiveness, replicability, and motivations. The goal is to provide improved understanding of which types of actions are most likely to be successfully implemented.

Specifically, the objectives of the research are to determine:

1. Which climate change adaptations are being implemented in coastal communities?

An inventory of adaptation best practices is compiled. Best practices were defined as initiatives such as studies, laws, policies, outreach tools or infrastructure investments that were voluntarily adopted by a local government and either not required or more stringent than state or federal law.

2. Based on an Intergovernmental Panel on Climate Change typology, what types of adaptation strategies are most common?

The Intergovernmental Panel on Climate Change identified three types of strategies to adapt to sea level rise: accommodation, protection, and retreat.²⁸ Which category each adaptation found falls within was identified and the classification system was expanded to include two new strategies - prevention and procedural.

3. What practice types are most common?

All of the adaptations are categorized into one of six different domains of action: Study/pilot project, Incorporating Climate Change into Existing Plans, Education/Outreach, Capital Investments, Policies and Laws.

²⁸ J. Dronkers, J. T. E. Gilbert, L.W. Butler, J.J. Carey, J. Campbell, E. James, C. McKenzie, R. Misdorp, N. Quin, K.L. Ries, P.C. Schroder, J.R. Spradley, J.G. Titus, L. Vallianos, and J. von Dadelszen, "Strategies for Adaption To Sea Level Rise. Report of the IPCC Coastal Zone Management Subgroup: Intergovernmental Panel on Climate Change," (Geneva: Intergovernmental Panel on Climate Change, 1990): iv. Accessed March 29, 2016: <u>http://papers.risingsea.net/IPCC-1990-Strategies-for-Adaption-to-Sea-Level-Rise.html</u> Intergovernmental Panel on Climate Change 1990.

4. What is the enforcement strength of actions?

Actions were categorized from strongest to weakest as mandatory, implemented, incentives, permissive, advisory, or proposed.

5. Do adaptations specifically incorporate climate change information or do they respond only to discernible risks such as flooding?

Adaptations were classified by whether they incorporate climate change explicitly. Included are both adaptation activities that could have an impact on climate change or sea level rise adaptation as well as those that were explicitly designed to do so.

6. What are the drivers of local climate adaptation practices?

We determined what motivates communities to take action, such as constituent pressure, elected official advocacy, funding or mandates from higher levels of government.

7. What are the legal implications of these adaptation strategies?

This section addresses constitutional issues, in particular the takings clause of the Fifth Amendment of the Constitution, that may pose a challenge to adaptation policies that limit development in vulnerable coastal zones.²⁹

²⁹ Lara D. Guercio, "Climate change adaptation and coastal property rights: A Massachusetts case study," *Boston College Environmental Affairs Law Review* 40, no. 2 (2013): 350-401, 366.

8. What is the current state of climate adaptation law in the ten states in the North Atlantic?

All ten states in the North Atlantic have taken action to adapt to climate change. We examine to what extent planning has been formalized and implemented in state law, and its impact on communities.

9. Did communities recovering from Sandy propose projects consistent with findings from the pre-Sandy portion of the research?

We determined whether communities recovering from Sandy chose implementable projects that were low cost and high benefit, using criteria partly developed in the first portion of this dissertation.

10. What does this pre-and post-Sandy experience tell us about the future?

Overall analysis is conducted and conclusions are drawn to suggest the best possible direction for the future of coastal communities.

1.3. ORGANIZATION OF THE DISSERTATION

This dissertation is divided into eight chapters. Chapter 1 provides the introduction. The second chapter provides background and a literature review on the subject of coastal climate change adaptation and the implications for land use planning. Chapter 3 provides an introduction to the legal background of coastal adaptation in the United States. Methods are described in chapter 4, including subsections on research design, the scope of the study, data collection and data categorization. Findings and discussion are presented in chapter 5. Chapter 6 summarizes a subsequent study that extends the research presented in the prior chapters. Chapter 7 provides an analysis of legal implications of

the methods of implementing adaptation described in the study. Chapter 8 presents overall analysis, conclusions, and recommendations for future work.

CHAPTER 2-BACKGROUND AND LITERATURE REVIEW

2.1. THE SCIENCE OF CLIMATE CHANGE

The devastation wrought by Hurricane Sandy has galvanized public discourse about the impact of climate change on coastal communities, and dramatically increased awareness of vulnerability to coastal hazards amongst citizens and officials alike, although science on the increasing risk has been warning of such an event for nearly as long.

Research identifying the warming of the earth's atmosphere has been accumulating for over two decades. In 1999, Mann, Bradley and Hughes published *Northern Hemisphere Temperatures During the Past Millennium*, widely viewed as the seminal work documenting and predicting the recent meteoric rise in observed temperatures.³⁰ They found that the northern hemisphere during the late 20th century was warmer than at any other time during the past millennium.³¹ They concluded:

Though expanded uncertainties prevent decisive conclusions for the period prior to AD 1400, our results suggest that the latter 20^{th} century is anomalous in the context of at least the past millennium. The 1990s was the warmest decade, and 1998 the warmest year, at moderately high levels of confidence. The 20^{th} century warming counters a millennial-scale cooling trend which is consistent with long-term astronomical forcing.³²

³⁰ Michael E. Mann, Raymond S. Bradley, and Malcolm K. Hughes, "Northern hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations," *Geophysical Research Letters* 26, no. 6 (1999): 759-762.

³¹ Ibid.

³² Ibid., 759.

While the work of Mann, Bradley, & Hughes has been subject to criticism and debate, scientific consensus on the existence and causes of global climate change has solidified. The United Nations Intergovernmental Panel on Climate Change (IPCC) said in report that "Warming of the climate system is unequivocal, and that the probability that this [warming] is caused by natural climatic processes alone is less than 5%."³³

Climate change is predicted to have a host of significant impacts around the globe - but sea level rise, first discovered thirty years ago³⁴ is expected to be amongst the most pernicious.³⁵ Sea level rise is expected to occur because of

³³ Intergovernmental Panel on Climate Change, *The physical science basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (1), Cambridge, UK and New York, NY, 2013. Accessed March 29, 2016: http://www.climatechange2013.org/report/full-report/

³⁴ See Michael C. Barth, and James G Titus. (Eds.) Greenhouse effect and sea level rise: A challenge for this generation (Van Nostrand Reinhold, New York, 1984); J. D. Milliman, J. M. Broadus, and F. Gable, "Environmental and economic implications of rising sea level and subsiding deltas: The Nile and Bengal examples," Ambio 18, no. 6 (1989): 340-345; R. A. Warrick, E. M. Barrow, & T. M. L. Wigley, eds., Climate and sea level change: Observations, projections, implications (United Kingdom: Cambridge University Press, 1993). ³⁵ See Susmita Dasgupta, Benoit Laplante, Craig M. Meisner, David Wheeler, and David J. Yan, "The impact of sea level rise on developing countries: a comparative analysis," *Climate* Change 93, no. 3 (2009): 379–388. Accessed March 30, 2016. doi:10.1007/s10584-008-9499-5; N. L. Mimura, R. F. Nurse, J. McLean, J. Agard, P. Briguglio, P. Lefale, R. Payet and G. Sem, "Small islands," in Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change, eds. M. L Parry et al. (United Kingdom: Cambridge University Press, 2007), 687-716; R. J. Nicholls, P. P. Wong, V. R. Burkett, J. O. Codignotto, J. E. Hay, R. F. McLean, C.D. Woodroffe, "Coastal systems and low-lying areas," in Parry, M.L et al, Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (United Kingdom: Cambridge University Press, 2007); Robert J. Nicholls, "Sea level rise and coastal zone management," in G. Ingram & Y. Hong (Eds.), Climate change and land policies (Cambridge, MA: Lincoln Institute of Land Policy, 2014), 34.



Global Average Absolute Sea Level Change, 1880–2014

Data sources:

 CSIRO (Commonwealth Scientific and Industrial Research Organisation). 2015 update to data originally published in: Church, J.A., and N.J. White. 2011. Sea-level rise from the late 19th to the early 21st century. Surv. Geophys. 32:585–602. www.cmar.csiro.au/sealevel/sl_data_cmar.html.

 NOAA (National Oceanic and Atmospheric Administration). 2015. Laboratory for Satellite Altimetry: Sea level rise. Accessed June 2015. http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/LSA_SLR_timeseries_global.php.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

Figure 3 - Trends in Global Average Sea Level (1970-2008)

Source: U.S. Environmental Protection Agency, "Climate Change Indicators in the United States." (June 2015) https://www3.epa.gov/climatechange/science/indicators/oceans/sea-level.html

the thermal expansion of seawater as it warms and melting of land-based ice, small glaciers, the Greenland ice sheet, and the West Antarctic ice sheet.³⁶ The consequences of this will dramatically affect coastal communities. As the IPCC noted in 1996:

Anticipated climate changes will greatly amplify risks to coastal populations...a 2-5-fold increase in rates of global sea level rise could

³⁶ G. A. Meehl, T. F. Stocker, W.D. Collins, and P. Friedlingstein, "Climate change 2007: The physical science basis," in S. Solomon et al., *Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press: Cambridge and New York, 2007), 749-844. Accessed March 29, 2016 https://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

lead to inundation of low-lying coastal regions, including wetlands, more frequent flooding due to storm surges, and worsening beach erosion.³⁷

These findings were reiterated in the most recent IPCC report.³⁸ Impacts to coastal communities include submergence, flood damage, saltwater intrusion, rising water tables, wetland loss, and accelerated coastal erosion.³⁹ Hinkel et al. estimate that erosion due to sea level rise will cause the loss of between 6,000 to 17,000 km² of coastal lands, resulting in the forced migration of between 1.6 and 5.3 million people.⁴⁰ On the East Coast of the United States, a more significant question may be how climate change will affect the frequency and severity of tropical cyclones. As stated by Anthes et al., "it would not be surprising if a warmer and moister world contained enhanced overall hurricane activity" because tropical cyclones gain energy from warm sea

³⁷ Intergovernmental Panel on Climate Change, *Climate change 1995: Impacts, adaptations and mitigation of climate change: Scientific-technical analyses,* United Kingdom: Cambridge University Press (1996), 878.

³⁸ Intergovernmental Panel on Climate Change, "Summary for Policymakers," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, (Cambridge, United Kingdom and New York, NY. USA: Cambridge University Press, 2014), 1-32.*

³⁹ Robert J. Nicholls and Anny Cazenave, "Sea-Level Rise and Its Impact on Coastal Zones," *Science* 328 (June 18, 2010), 1517-1520.

⁴⁰ Jochen Hinkel, Robert J. Nicholls, Richard S. J. Tol, Zheng B. Wang, Jacqueline M. Hamilton, Gerben Boot, Athanasios T. Vafeidis, Loraine McFadden, Andrey Ganopolski, and Richard J. T. Klein, "A Global Analysis of Erosion of Sandy Beaches and Sea-Level Rise: An Application of DIVA." *Global and Planetary Change* 111 (December, 2013): 150–58. doi:10.1016/j.gloplacha.2013.09.002.

surface temperatures.⁴¹ Emanuel⁴² and Webster et al.⁴³ suggest that tropical cyclone intensity has increased since the 1970s. The latter found that there was a large increase in the number and proportion of category 4 and 5 storms in the past 35 years.

Knutson and Tuleya (2004) conducted a modeling study that indicated wind speed and rainfall will rise with the projected increasing carbon in the atmosphere.⁴⁴ Their results indicated a 6% increase in maximum tropical cyclone wind speed. Anthes et al. wrote that "this broad consistency between observations, models, and theory is a powerful indicator that we are likely already experiencing more intense tropical cyclones as a result of global warming."⁴⁵ Mann and Emanuel⁴⁶ and Knutson et al.⁴⁷ concluded that climate change is the likely cause of an increase in long-term trends in tropical cyclone activity and intensity. Mendelsohn et al. developed a tropical cyclone

⁴¹ Anthes, Richard A., Robert W. Corell, Greg Holland, James W. Hurrell, Michael C.
MacCracken, and Kevin E. Trenberth. "Hurricanes and global warming: Potential linkages and consequences." *Bulletin of the American Meteorological Society* 87, no. 5 (2006): 623-628.
⁴² Emanuel, Kerry. "Increasing destructiveness of tropical cyclones over the past 30 years." *Nature* 436, no. 7051 (2005): 686-688.

⁴³ Webster, Peter J., Greg J. Holland, Judith A. Curry, and H-R. Chang. "Changes in tropical cyclone number, duration, and intensity in a warming environment." *Science* 309, no. 5742 (2005): 1844-1846.

 ⁴⁴ Knutson, Thomas R., and Robert E. Tuleya. "Impact of CO₂-induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization." *Journal of Climate* 17, no. 18 (2004): 3477-3495.
 ⁴⁵ Ibid., 624.

⁴⁶ Mann, Michael E., and Kerry A. Emanuel. "Atlantic hurricane trends linked to climate change." *EOS, Transactions American Geophysical Union* 87, No. 24 (2006): 233-241.

⁴⁷ Thomas R. Knutson, John L. McBride, Johnny Chan, Kerry Emanuel, Greg Holland, Chris Landsea, Isaac Held, James P. Kossin, A. K. Srivastava, and Masato Sugi, "Tropical cyclones and climate change." *Nature Geoscience* 3, no. 3 (2010): 157-163.

integrated assessment model to determine how the frequency, intensity and location of tropical cyclones might change due to climate change. ⁴⁸ The aggregated data suggested that storm power will increase substantially in the North Atlantic specifically. NOAA stated that the likely result:

[A]s coastal storms become more intense...damage to the built and natural environments from flooding, erosion, and high winds will become more commonplace. Consequences of these storms may include injuries and loss of life as well as damage to and destruction of coastal property and infrastructure.⁴⁹

While climate-related losses may be increasing, research on question of the relative role of increasing vulnerability vs. climate effects continues to be debated. Some research demonstrates that climate change does play a role - after adjusting for the fact that there is an increase in adaptation, or resilience, as growth occurs, Estrada et al. found that increase in losses cannot be explained by economic growth alone.⁵⁰ They identified an upward trend in both the number and intensity of hurricanes in the North Atlantic basin as well as economic losses between 1900 and 2005. They concluded "the variety of statistical models we present suggest that part of the increase in hurricane and storm losses in the US is at least consistent with observed global warming."⁵¹

⁴⁸ Mendelsohn, Robert, Kerry Emanuel, Shun Chonabayashi, and Laura Bakkensen. "The impact of climate change on global tropical cyclone damage." *Nature Climate Change* 2, no. 3 (2012): 205-209.

⁴⁹ National Oceanic and Atmospheric Administration (NOAA), "Adapting to climate change: A planning guide for state coastal managers," NOAA Office of Ocean and Coastal Resource Management (2010), 13. Accessed March 30, 2016:

http://coastalmanagement.noaa.gov/climate/adaptation.html

⁵⁰ Estrada, Francisco, W.J. Wouter Botzen, and Richard S.J. Tol. "Economic losses from US hurricanes consistent with an influence from climate change."*Nature Geoscience*, (2015). ⁵¹ Ibid., 883.

Stéphane Hallegatte posits that alterantive hypotheses for the increasing losses are plausible, including one related to the location of hurricane landfalls: "[T]he same number of storms with the same intensity would lead to much larger losses if they made landfall over less-prepared areas with less-resistant houses and lower seawalls."⁵² She says this 'localization' effect played a key role in past assessments of hurricane losses.⁵³ Regardless, while researchers continue to search for evidence that climate change is responsible for some portion of increasing losses, there is no question that the majority of that increase is due to increasing vulnerability due to land use and development decisions.

The observation that it is largely increasing exposure to hazards that put people in harm's way is not new. Geographer Gilbert F. White famously wrote "floods are 'acts of god,' but flood losses are largely acts of man..."⁵⁴ White was writing about riverine flooding, but his axiom is as apt with regard to coastal floods. As Haughton and Hunter observed, the greatest increasing exposure to climate threats is not climate change itself, but increasing the urbanization of

 ⁵² Hallegatte, Stéphane. "Climate change: Unattributed hurricane damage." Nature Geoscience 8, no. 11 (2015): 819-820., 820.
 ⁵³ Ibid.

⁵⁴ Gilbert F. White, "Human Adjustment to Floods," Department of Geography Research Paper no. 29. Chicago: University of Chicago, 1945.
coastal areas.⁵⁵ Huq et al. explain there are four main reasons cities are located in locations at risk from flooding and storms.⁵⁶ First, coastal locations were attractive settlers for a number of reasons, including transportation access for trade, for territorial control, ready supplies of fresh water, or fertile deltas. Although railways and air transport have changed the costs and benefits of coastal locations, seaports are still a major part of the global economy. Second, settlements often outgrow originally safe locations and expand onto at-risk land such as floodplains, often also through lanndfill. Third, once a city develops, it rarely disappears, even if it experiences disasters, because too many individuals and institutions have roots and a stake in the place. Fourth, wealthier groups and formal enterprises face far less serious risks than the poor. ⁵⁷

Coastal areas have been found to be the most populated and economically active zones on earth. That trend has not abated in recent years, despite increasing reliance on air and road over maritime transport of goods and people.⁵⁸ Even in the 21st century, when waterborne transport represents a

 ⁵⁵ Haughton, Graham and Colin Hunter. Sustainable Cities. London, UK: Routledge, 2004.
 ⁵⁶ Huq, Saleemul, Sari Kovats, Hannah Reid, and David Satterthwaite. "Editorial: Reducing risks to cities from disasters and climate change." Environment and Urbanization 19, no. 1 (2007): 3-15.

⁵⁷ Ibid.

⁵⁸ McGranahan, Gordon, Deborah Balk, and Bridget Anderson. "The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones." *Environment and Urbanization* 19, no. 1 (2007): 17-37.

small fraction of economic activity, coastal cities are the population and economic engines of the world.⁵⁹

Amongst the nations of the world, China has the largest urban population, nearly 80 million, living in the low elevation coastal zone, and it is growing quickly. India follows with over 30 million individuals in the low-elevation zone. The US has just over 20 million people living in the high risk area - more than nations considered at very high risk of coastal climate change impacts including Bangladesh, Vietnam, Thailand and the Netherlands, but fewer than Japan and Indonesia, which have over 20 million people each.⁶⁰

⁵⁹ Jeffrey D. Sachs, Andrew D. Mellinger, and John L. Gallup, "The geography of poverty and wealth," *Scientific American* (March 1, 2001): 71-74.

⁶⁰ Nicholls, Robert J., Susan Hanson, Celine Herweijer, Nicola Patmore, Stéphane Hallegatte, Jan Corfee-Morlot, Jean Château, and Robert Muir-Wood. "Ranking port cities with high exposure and vulnerability to climate extremes: exposure estimates," OECD Environment Working Papers (2008), doi:10.1787/011766488208.

As a result of intense development of coasts worldwide, much of our vulnerable and sensitive ecosystems have been compromised. A Pew Oceans Commission study on the U.S. coast found that the coastal watersheds of the Mid-Atlantic were 30 percent developed.⁶¹ New England's coastal watersheds were 17% developed, the South Atlantic and Gulf Coast region was 12.5% developed and California's wetlands were 15% developed.⁶² These trends are particularly disconcerting, since coastal wetlands provide one of the primary defenses against climate change and its associated threats such as coastal flooding.



Figure 4 – Population living less than 3.3 feet above mean high water

Source: Cleetus, Rachel. "Overwhelming Risk: Rethinking Flood Insurance in a World of Rising Seas." Union of Concerned Scientists, 2013. Accessed from: http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Overwhelming-Risk-Full-

<u>Report.pdf.</u> (March 23, 2016.)

In the United States, coastal areas comprise less than 20% of the country's

land area but are home to more than 50% of the population.⁶³ Fifty one percent

⁶¹ The Pew Charitable Trusts, *America's living oceans: Charting a course for sea change*, Arlington, VA, May 2003.

⁶² Ibid.

⁶³ Rappaport, Jordan and Jeffrey D. Sachs, "The United States as a coastal nation," *Journal of Economic Growth* 8 no. 5 (2003): 46.

of the 2000 population and 57% of civilian income are located in a county within eighty kilometers of the shore of either an ocean or the Great Lakes.⁶⁴ More than 164 million residents and more than 180 million tourists visit the coastal zone annually.⁶⁵

In the lower 48 US states, there are nearly 5 million people, living in 2.6 million homes, at less than 4 feet above high tide; and 3.7 million live below 1 meter above high tide.⁶⁶ Given moderate sea level rise projections of an average of 3.3 feet by 2100 due to global climate change, this entire area could be flooded.⁶⁷

The entire U.S. Gulf and Atlantic coast from Texas to Maine is highly vulnerable to devastating tropical cyclones, and inflation-adjusted losses have been increasing exponentially over the past 50 years.⁶⁸ Historically, the highest-loss regions from coastal storms are the northern Gulf Coast and

⁶⁶ Strauss, Benjamin H., Remik Ziemlinski, Jeremy L. Weiss, and Jonathan T. Overpeck. "Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States." *Environmental Research Letters* 7, no. 1 (2012): 014033.

⁶⁴ Ibid.

⁶⁵ Moser, Susanne C., Margaret. A. Davidson, P. Kirshen, P. Mulvaney, J. F., Murley, J.E. Neumann, and D. Reed, "Coastal zone development and ecosystems: Climate change impacts in the United States," in *The Third National Climate Assessment*, ed. J.M. Mehillo et al. (Washington D.C.: Global Change, 2014), 579-618.

⁶⁷ Tebaldi, Claudia, Benjamin H. Strauss, and Chris E. Zervas. "Modelling sea level rise impacts on storm surges along US coasts." *Environmental Research Letters* 7, no. 1 (2012): 014032.

⁶⁸ Pielke Jr, Roger A., and Christopher W. Landsea. "Normalized hurricane damages in the United States: 1925-95." Weather and Forecasting 13, no. 3 (1998): 621-631.

southern Florida. ⁶⁹ The west coast also has high loss values, but these arise because of geophysical events and not storm-related damage. On the Atlantic coast, 69% of hazard losses are caused by hurricanes and tropical storms.⁷⁰

Pielke et al. provided longitudinally consistent estimates of economic damage that past storms would have under current levels of population and development, and suggest there has been "tremendous pace of growth in societal vulnerability to hurricane impacts."⁷¹ Independent analysis of insured losses suggests they are doubling every 10 years, because of increases in construction cost, number of structures, and changes in their characteristics.⁷²

They concluded that "avoiding huge losses will require either a change in the rate of population growth in coastal areas, major improvements in construction standards, or other mitigation solutions...Unless action is taken to address the growing concentration of people and properties in coastal areas...damage will increase, and by a great deal, as more and wealthier people inhabit these coastal locations."⁷³

⁶⁹ Cutter, Susan L., Laurie A. Johnson, Christina Finch, and Melissa Berry. "The US hurricane coasts: increasingly vulnerable?" *Environment: Science and Policy for Sustainable Development* 49, 7 (2007): 8-21.

⁷⁰ Ibid.

⁷¹ Pielke Jr, Roger A., Joel Gratz, Christopher W. Landsea, Douglas Collins, Mark A. Saunders, and Rade Musulin. "Normalized hurricane damage in the United States: 1900–2005." *Natural Hazards Review* 9, no. 1 (2008): 29-42.

 $^{^{72}}$ "Sound risk management, strong investment results prove positive for P/C industry." (2006). *Insur. J.*

⁷³ Pielke et al., "Normalized hurricane damage," 38.

These challenges of actually increasing exposure to risk exist not only on the national scale, but the urban scale as well. This is especially the case in the parts of cities that are low-lying, below-sea level or immediately exposed barrier islands. It is unlikely, given the existing investments and political frameworks, that we can even slow population movement towards the coasts; it is even less likely that we will reverse the trends of already existing development in the coastal zone. Given the combined impacts of continued coastal development and climate change, communities are going to have to learn to adapt to survive.

2.2. ADAPTATION AS THE SOLUTION

As defined by the IPCC, adaptation is "adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."⁷⁴ The importance of adaptation measures is underscored by the long atmospheric residence times of greenhouse gases and the fact that any reduction to emissions is "unlikely to lead to measurable results for many decades."⁷⁵ As the Commonwealth of

⁷⁴ McCarthy, James J., Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White. "Contribution of working group II to the third assessment report of the intergovernmental panel on climate change (IPCC)."*Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) Cambridge University Press, London, UK* (2001): 1000., 72.

⁷⁵ Stone Jr, Brian. "Urban heat and air pollution: an emerging role for planners in the climate change debate." *Journal of the American planning association* 71, no. 1 (2005): 13-25, 23. doi:10.1080/01944360508976402

Massachusetts Climate Change Adaptation Plan noted, the effects of climate change are already with us, "in the form of hotter summers, rising sea levels, more frequent flooding, and warmer winters."⁷⁶ In addition:

extensive areas of beachfront are lost to coastal erosion and some groundwater supplies are rendered undrinkable by saltwater intrusion. Every summer, 5 to 20 days now reach over 32° C (90°F), nearly double of what it was 45 years ago. This results in poor air quality and causes significant respiratory and cardiovascular health problems, especially for children and the elderly.⁷⁷

As early as 1995, in its second assessment report, the IPCC also emphasized the importance of adaptation as "a very powerful option for responding to climate change."⁷⁸ Article 11 of the Kyoto Protocol also commits parties to promote and facilitate adaptation to address climate change.⁷⁹

The observation that cities can adapt to climate change impacts, such as

increased flooding, is not at all new. As Gilbert White wrote in 1945:

The effect of floods are not everywhere disastrous...or even disturbing to the economy. Each year ebbing flood waters also reveal plains in which a relatively satisfactory arrangement of human occupance has taken place. Pittsburgh merchants returning to stores where, because of adequate preparations, suffered only minor losses; Montana ranchers appraising

⁷⁶ Massahusetts Executive Office of Energy and Environmental Affairs. "Massachusetts climate change adaptation report," 1-121, 8. Retrieved from:

http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf ⁷⁷ Ibid, 8.

⁷⁸ Intergovernmental Panel on Climate Change (IPCC), "Climate change 1995: Impacts, adaptations and mitigation of climate change: Scientific-technical analyses." Contribution of working group II to the second assessment of the intergovernmental panel on climate change. Cambridge University Press. 1995. Accessed

https://www.ipcc.ch/ipccreports/sar/wg II/ipcc sar wg II full report.pdf : Cambridge. U.K. ⁷⁹ United Nations Framework Convention on Climate Change. United Nations (9 May 1771 UNTS 107; S. Treaty Doc No. 102-38; U.N. Doc. A/AC.237/18 (Part II)/Add.1; 31 ILM 849 (1992). Accessed March 30, 2016: https://unfccc.int/resource/docs/convkp/conveng.pdf)

the increased yields of hay to be obtained because of fresh deposits of moisture; and New Orleans citizens carrying out their business behind a levee withstanding a flood crest high above the streets, illustrate wise adjustments to flood hazard.⁸⁰

White provided a set of strategies to reduce vulnerability to flooding, all of which seem as relevant today and applicable to the challenges of climate change:

(1) elevating land above the level of likely floods; (2) managing land upstream to abate flood flows; (3) protecting flood plains by levees, channel improvements, and reservoirs; (4) taking emergency measures to create temporary protection and evacuate people and property; (5) making physical structures less exposed to floods; (6) using flood plain lands for low-damage uses; (7) providing relief for flood victims; and (8) insurance for flood losses. White also believed that public policy should consider not just costs that are easy to measure but the total social costs and benefits in implementing 'adaptation' actions, a veritable and timeless perspective.⁸¹

White wrote in an era before climate change was discovered, and since then many researchers have advanced adaptation theory. Researchers have distinguished three types of climate change adaptation, including: anticipatory, autonomous and planned adaptation.⁸² Anticipatory adaptation is adaptation that takes place before the impacts of climate change are felt. Autonomous adaptation, also known as spontaneous adaptation, does not constitute a conscious response to climatic stimuli but is triggered by

⁸⁰ Gilbert F. White, "Human Adjustment to Floods," Department of Geography Research Paper no. 29. Chicago: University of Chicago (1945), at p. 1.
⁸¹ Ibid, 1.

⁸² Smit, Barry, Ian Burton, Richard J.T. Klein, and Johanna Wandel. "An anatomy of adaptation to climate change and variability." *Climatic Change* 45, no. 1 (2000): 223-251.

ecological and market changes in human systems.⁸³ Planned adaptation anticipates impacts from climate change and involves making deliberate policy decisions to "maintain or achieve a desired state."⁸⁴

Urban and regional systems will likely experience all three type of adaptation as the climate changes, but certainly, the spontaneous adaptive measures, such as those taken by residents fleeing New Orleans in advance of Hurricane Katrina, are likely to be very costly and disruptive. Planned adaptation is clearly much preferable.

Adaptive capacity has also been defined and refers to "the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences."⁸⁵ Researchers, such as Yohe & Tol,⁸⁶ O'Brien et al.,⁸⁷

⁸³ Ibid.

 ⁸⁴ Intergovernmental Panel on Climate Change. Climate change: Impacts, adaptation and vulnerability, working group II contribution to the fourth assessment report of the intergovernmental panel on climate change, Cambridge, U.K.: 2007: Cambridge University Press. Retrieved from: <u>https://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html</u>
 ⁸⁵ "Glossary of Terms used in the IPCC Third Assessment Report," Intergovernmental Panel on Climate Change (IPCC), 365, accessed March 30, 2016,

<u>https://www.ipcc.ch/pdf/glossary/tar-ipcc-terms-en.pdf</u>.) (2001). Third Assessment Report, Annex B: Glossary of Terms.

⁸⁶ Yohe, Gary, and Richard S.J. Tol. "Indicators for social and economic coping capacity moving toward a working definition of adaptive capacity." *Global Environmental Change* 12, no. 1 (2002): 25-40.

⁸⁷ O'Brien, Karen, Robin Leichenko, Ulka Kelkar, Henry Venema, Guro Aandahl, Heather Tompkins, Akram Javed et al. "Mapping vulnerability to multiple stressors: Climate change and globalization in India." *Global Environmental Change* 14, no. 4 (2004): 303-313.

Janssen & Ostrom,⁸⁸ and Smit & Wandel⁸⁹ have identified specific elements of adaptive capacity, such as: availability and access to human and financial resources, flexible and appropriate institutions, strong networks and access to climate information.⁹⁰ Therefore, enhancing any of these capacities could be considered a climate change adaptation.

Much of the recent literature focuses on implementing actions that have been extensively studied. Smith et al. calls this moving 'from words to deeds' and cites a number of abilities to make it happen, such as being able to resolve conflicting perceptions, political objectives, and cultural support.⁹¹ Other

⁸⁸ Janssen, Marco A., and Elinor Ostrom. "Resilience, vulnerability, and adaptation: A crosscutting theme of the International Human Dimensions Programme on Global Environmental Change." Global Environmental Change 16, no. 3 (2006): 237-239. ⁸⁹ Smit, B., & Wandel J., (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16(3), 282-292. doi: 10.1016/j.gloenvcha.2006.03.008 ⁹⁰ See Gary Yohe, and Richard S. J. Tol, "Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity," Global Environmental Change I, 12 no. 1 (2002): 25-40, doi: 10.1016/S0959-3780(01)00026-7; O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L., & West, J. "Mapping vulnerability to multiple stressors: climate change and globalization in India," Global Environmental Change, 14 (2004): 303-313, doi: 10.1016/j.gloenvcha.2004.01.001.; Janssen, M.A., & Ostrom, E. "Resilience, vulnerability, and adaptation: a cross-cutting theme of the international human dimensions programme on global environmental change," Global Environmental Change 16 no. 3 (2006): 235-316.; Barry Smit and Johanna Wandel, "Adaptation, adaptive capacity and vulnerability," Global Environmental Change 16 no. 3 (2006): 282-292, doi: 10.1016/j.gloenvcha.2006.03.008. ⁹¹ See B.M. Haddad, "Ranking the adaptive capacity of nations to climate change when sociopolitical goals are explicit," Global Environmental Change Part A 15 no. 2 (2005): 165–176; B. Menne and R. Bertollini, "Health and climate change: A call for action," British Medical Journal 331 (2005): 1283–1284.; A. Patt and S. Dessai, "Communicating uncertainty: Lessons learned and suggestions for climate change assessment," Geoscience 337 no. 4 (2005): 425–441; S. Burch and J. Robinson, "A framework for explaining the links between capacity and action in response to global climate change," Climate Policy 7 no. 4 (2007): 304– 316; H.M. Füssel, "Adaptation planning for climate change: concepts, assessment, approaches, and key lessons," Sustainability Science 2 No. 2 (2007): 265-275; D. R. Nelson, W.N. Adger, and K. Brown, "Adaptation to environmental change," Annual Review of Environment and Resources 32(2007): 395–419; Smith, J. B., Ragland, S. E. & Pitts, G. J.

researchers that have addressed these issues include Haddad,⁹² Menne & Bertollini,⁹³ Patt & Dessai,⁹⁴ Burch & Robinson,⁹⁵ Füssel,⁹⁶ and Nelson et al.⁹⁷ What types of adaptation actions to sea level rise and climate change are available to communities?

How communities choose to rebuild after will define whether they adapt to the new ecological reality or continue to deny and defend against it. The IPCC identified three types of adaptive actions to deal with the threat of sea level rise: accommodation, protection, and retreat.⁹⁸ Protection is by far the most costly adaptation option, involving expensive engineering projects such as sea walls and dikes. Protection also includes construction or maintenance of natural solutions such as living shorelines or dunes and vegetation.

⁹² Haddad, Brent M. "Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit." *Global Environmental Change* 15, no. 2 (2005): 165-176.
⁹³ Menne, Bettina, and Roberto Bertollini. "Health and climate change: a call for action: The

^{(1996).} A process for evaluating anticipatory adaptation measures for climate change. *Water, Air and Soil Pollution*, 92, 229–238. doi:10.1007/BF00175568.

health sector has to become proactive, not reactive." *BMJ: British Medical Journal* 331, no. 7528 (2005): 1283.

⁹⁴ Patt, Anthony, and Suraje Dessai. "Communicating uncertainty: lessons learned and suggestions for climate change assessment." *Comptes Rendus Geoscience* 337, no. 4 (2005): 425-441.

⁹⁵ Burch, Sarah, and John Robinson. "A framework for explaining the links between capacity and action in response to global climate change." *Climate Policy* 7, no. 4 (2007): 304-316.
⁹⁶ Füssel, H.M. (2007). "Adaptation planning for climate change: concepts, assessment, approaches, and key lessons." *Sustainability Science*, 2(2), 265–275.

⁹⁷ Nelson, Donald R., W. Neil Adger, and Katrina Brown. "Adaptation to environmental change: contributions of a resilience framework." *Annual review of Environment and Resources* 32, no. 1 (2007): 395.

⁹⁸ Intergovernmental Panel on Climate Change, "Strategies for adaptation to sea level rise: Report of the coastal zone management subgroup," IPCC Coastal Zone Management Subgroup. *Ministry of Transport and Public Works and Water Management:* The Hague, Netherlands (1990), 1-131.

Accommodation "implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded."⁹⁹ The IPCC cites constructing emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood or salt tolerant crops as examples of accommodation. And, retreat is defined as making "no effort to protect the land from the sea," allowing ecosystems to shift landward as the coastal zone is abandoned.¹⁰⁰ Programs that discourage or prohibit rebuilding are often called managed retreat. Unfortunately the word retreat, with its connotation of cowardliness, is a much-maligned term for a complex set of programs and regulations that might better be described as "restoration" since the objective of many such policies is to restore the natural coastal environment and the buffer that such habitat provides.

How to choose optimal adaptation, however, remains mired in political and economic complexity. Yohe, Neumann, & Marshall used a cost-benefit criterion to model the optimal response.¹⁰¹ They determined that, if the present value of the costs to protect property exceed the value of the protected property, the

⁹⁹ Ibid., IV.

¹⁰⁰ Ibid.

¹⁰¹ H. Ameden, P. Marshall, J. Neumann, and G. Yohe, "The economic damage induced by sea level rise in the United States" in *The Impact of Climate Change on the United States Economy*, eds. R. Mendelsohn & James E. Neumann (United Kingdom: Cambridge University Press, 1999), 178-208.

analysis argues for abandonment. However, as Hudgens and Neumann observe:

Real-world coastal zone decision-making is far more complex... [p]olitical influence, incomplete understanding of coastal risks, insurance markets, private and public infrastructure investments, and other factors all will likely influence the response decision.¹⁰²

To develop an in-depth understanding of the possible responses, they evaluated three scenarios and responses based on the enforcement of existing policies, the most likely state, county and individual reactions, and greater environmental and cultural values. They concluded that county-driven land use decisions will shape areas that will likely be developed and protected and those that will remain agricultural or open space and therefore abandoned.¹⁰³

2.3. ADAPTATION AND LAND USE PLANNING

Much of the adaptation research has taken place outside the discipline of urban planning and local government action. But researchers such as Fankhauser, Smith, and Tol who laid out a framework for the nature of how systems can begin to incorporate climate change adaptation, suggest the role for local government and the land use system will be significant.¹⁰⁴

¹⁰² Daniel E. Hudgens and James E. Neumann, "State and local-level planning for adapting to sea level rise: A case study of Delaware likely responses," *Coasts at the millennium: Proceedings of the Seventeenth International Conference of the Coastal Society* (Portland, OR USA, 2000), 250, accessed March 30, 2016

http://nsgl.gso.uri.edu/oresu/oresuc00002/pdffiles/papers/043.pdf. ¹⁰³ Ibid.

¹⁰⁴ Fankhauser, Samuel, Joel B. Smith, and Richard SJ Tol. "Weathering climate change: some simple rules to guide adaptation decisions." *Ecological economics* 30, no. 1 (1999): 67-78.

Their analysis indicates that climate change needs to be accounted for in longlived projects and investments sensitive to rapidly changing climate parameters. They suggest that buildings, infrastructure, and city development plans are all examples of such investments. In fact, they call out planning as being an especially essential element of anticipatory adaptation because it is inherently forward looking and puts investment projects into a programmatic context.

They also point out that the "main role for government will be to provide the right legal, regulatory and socio-economic environment to make autonomous adaptation possible."¹⁰⁵ Planning and local land use has a significant role to play in this regard, such as when a height limit regulation might prevent a homeowner from elevating his house above the floodplain.

The challenges toward effective adaptation are extremely complex and likely to be politically difficult. Planners and planning, however, are well equipped to deal with adaptation challenges.¹⁰⁶ As opposed to the case of climate change mitigation, which requires national and global action, municipalities are the relevant actors for adaptive actions. It is in cities and local communities where the impacts of climate change will be felt; their police and fire departments are

¹⁰⁵ Ibid., 74.

¹⁰⁶ See Hurlimann, Anna C., and Alan P. March. "The role of spatial planning in adapting to climate change." *Wiley Interdisciplinary Reviews: Climate Change*3, no. 5 (2012): 477-488.

the first responders in a crisis, and it is municipally-determined urban form, transportation and public health interventions that will stave off the worst effects of climate change. Spatial and urban planning will need to contribute significantly to the effective climate adaptation of our built environment. Regulations such as setback provisions, shoreline protection provisions, height limits, buffers, dune protection ordinances, and transfer or purchase of development rights are all potential avenues to advance adaptation in the coastal zone.

As Mileti (1999) states "No single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land-use management."¹⁰⁷ NOAA added: "The same is likely to hold true for climate change adaptation as well."¹⁰⁸ As the NOAA publication evidences, communities have already been advancing climate adaptation through the rubric of coastal zone management and hazard mitigation planning for years.

Local governments have been planning and regulating land use for nearly a century and have become increasingly sophisticated in their approaches. As

¹⁰⁷ Dennis S. Mileti, *Disasters by design, A reassessment of natural hazards in the United States* (Washington DC: Joseph Henry Press, 1999), 155.

¹⁰⁸ National Oceanic Atmospheric Administration, *A Planning Guide for State Coastal Managers*, (Silver Spring MD: NOAA Office of Ocean and Coastal Resource Management, 2010), accessed March 30, 2016, <u>https://coast.noaa.gov/czm/media/adaptationguide.pdf</u>.

many scholars of land use have noted, the tools to deal with climate change adaptation are already in their coffers. Municipalities can use existing legal and planning systems to handle the impacts of a changing climate. As Thomas Gremillion explains in his article *Setting the Foundation: Climate Change*

Adaptation at the Local Level:

Local governments can use their authority to dictate how and where to construct buildings and infrastructure to undertake flood planning and control, strengthen buildings to withstand major storm events, and prevent ridgeline development susceptible to landslides. The tools for undertaking this planning are the basic stuff of local government administration—comprehensive plans, floodplain regulations, zoning, building codes, overlay zones, and stormwater regulations. These tools also play a fundamental role in broader environmental protection and GHG mitigation initiatives, such as wetlands preservation.¹⁰⁹

How municipalities should go about incorporating climate change into their

planning frameworks have been described by Bacher.¹¹⁰ She lays out a ten-step

approach for municipalities seeking to adopt climate change adaptation and

hazard mitigation strategies. She suggests that municipalities:

- 1. Adopt policy resolution or mayoral proclamation
- 2. Appoint a task force and authorize studies
- 3. Adopt a moratorium to allow time for planning and adopting new regulations
- 4. Decide whether the comprehensive plan needs to be amended
- 5. Adopt a comprehensive plan sea level rise component
- 6. Adopt expanding overlay zone for sea level rise vulnerable areas
- 7. Adopt application requirements and standards for special use permits

 $^{^{109}}$ Gremillion, Thomas M. "Setting the foundation: Climate change adaptation at the local level," *Environmental L.* 41 no. 4 (2011), 1221-1253, 1235.

¹¹⁰ Bacher, Jessica A. "Yielding to the rising sea: The land use challenge," *Real Estate Law Journal*, 38 no. 93 (2009).

- 8. Amend site plan and subdivision regulations to cross reference special permit requirements
- 9. Place limitations on rebuilding in the overlay zone if there is substantial destruction of a structure
- 10. Establish a moratorium following future storm events¹¹¹

Although a ten-step approach might be ideal, local governments will in reality be making decisions on how to adapt to long-term climate change in the shortterm. This underscores the need to ensure current regulations account for future conditions.

As Titus observed:

Although sea level is not expected to rise rapidly until after 2000, resort communities may have to consider its consequences much sooner. After the next major storm, in particular, homeowners whose properties are destroyed will decide whether and how to rebuild and local governments will decide whether or not to let all of them rebuild, and which options are appropriate to address the storm-induced erosion.¹¹²

The question of what land uses lead to better outcomes in the face of coastal hazards apart from sea level rise and climate change has been examined by a number of researchers. Research is mixed and the answers are nuanced. Brody, Gunn, Peacock and Highfield conducted an empirical study examining the relationship between development intensity and flood damage in 144

¹¹¹ Ibid.

¹¹² Titus, James G. "Planning for sea level rise before and after a coastal disaster," in *Greenhouse Effect and Sea Level Rise: A Challenge for This Generation*, Michael C. Barth and James G. Titus (eds.) (New York: Van Nostrand Rhinehold Company, 1984), 253-565, at p. 253.

counties and parishes fronting the Gulf of Mexico.¹¹³ They used linear regression to control for the effects of environmental and socioeconomic variables to determine the effects of urban character. They concluded "...as long as dense urban development is situated away from vulnerable areas (such as the floodplain), this built-environment pattern can lead to more resilient local communities over the long term."¹¹⁴ They found property damage was lower in denser communities and higher in low-density, sprawling places. On the other hand, Burby, Nelson, Parker and Handmer argue that smart growth and urban containment may have the "serious side-effect" of leading to increased exposure to and losses from hazards and disasters and conclude that urban planners pay too little attention to hazard mitigation in places with containment policies.¹¹⁵ This tells us that hazards from climate change are essentially spatial in nature, and therefore the optimal response is locally dependent.

The optimal choices can be made at the local level, but unless the risks have been considered, the community will not be prepared. The evidence suggests that long-term comprehensive planning does matter and reduces overall risks.

¹¹³ Brody, Samuel D., Joshua Gunn, Walter Peacock, and Wesley E. Highfield. "Examining the influence of development patterns on flood damages along the Gulf of Mexico." *Journal of Planning Education and Research* (2011): 0739456X11419515. ¹¹⁴ Ibid., 8.

¹¹⁵ Burby, Raymond J., Arthur C. Nelson, Dennis Parker, and John Handmer. "Urban containment policy and exposure to natural hazards: is there a connection?" *Journal of Environmental Planning and Management* 44, no. 4 (2001): 475-490.

Burby and Dalton analyzed the natural experiment that results from a comparison of states that mandate comprehensive planning and those that do not.¹¹⁶ They specifically addressed planning for natural hazards including flooding, hurricanes and seismic risk, such as limiting allowed building in high hazard areas, or density bonuses to compensate for limits in hazardous zones and property tax abatements for protecting open space in hazard zones. Of 176 jurisdictions, only 52% had one of these measures in place and 37% restricted density in high hazard areas.¹¹⁷

Olshansky found that planning matters in a qualitative study of communities' planning in advance of the Northridge earthquake.¹¹⁸ Steinberg and Burby reported that despite the logic of using comprehensive planning to attend to hazard mitigation, many local governments fail to plan, fail to update plans, and fail to implement those plans in a way that reduces losses from disasters.¹¹⁹ This is a somewhat surprising finding, since local governments would appear to be the locus for such losses and would be expected to be pressured to act to protect citizens and their property. However, a number of

¹¹⁶ Burby, Raymond J., and Linda C. Dalton. "Plans can matter! The role of land use plans and state planning mandates in limiting the development of hazardous areas." *Public administration review* (1994): 229-238.

¹¹⁷ Ibid.

¹¹⁸ Olshansky, Robert B. "Land use planning for seismic safety: The Los Angeles County experience, 1971–1994," *Journal of the American Planning Association* 67, no. 2 (2001): 173-185.

¹¹⁹ Steinberg, Michelle and Raymond Burby, "Growing Safe," *Planning* 68 no. 4 (2002):22–23.

researchers, including Berke, ¹²⁰ Birkland, ¹²¹ May & Williams, ¹²² Berke & Beatley, ¹²³ and Godschalk et al.¹²⁴ have found that hazard mitigation is seen as a low priority and not acted upon.

Local governments have the power and capacity to build a bold future to reduce their vulnerability and increase their resilience to a changing climate. With regard to land use or spatial planning, there are a number of potential areas of action that are relevant to climate adaptation. Regulations such as setback provisions, shoreline protection provisions, height limits, buffers, dune protection ordinances, and transfer or purchase of development rights are all potential avenues to advance adaptation in the coastal zone. Wetlands protection, stormwater management and floodplain management are additional mechanisms for adapting to a changing climate.

management." *Journal of the American Planning Association* 64, no. 1 (1998): 76-87. ¹²¹ Birkland, Thomas A. "Natural disasters as focusing events: Policy communities and political response," *International Journal of Mass Emergencies and Disasters* 14 no. 2 (1996): 221-243.

¹²⁰ Berke, Philip R. "Reducing natural hazard risks through state growth

 ¹²² May, Peter J., and Walter Williams, Disaster Policy Implementation: Managing Programs Under Shared Governance. Springer Science and Business Media (New York: 2012).
 ¹²³ Berke, Phillip and Timothy Beatley, Planning for Earthquakes: Risk, Politics and Policy (Baltimore, MD: Johns Hopkins University Press, 1992).

¹²⁴ Burby, Raymond J., Steven P. French, and Beverly A. Cigler. *Flood plain land use management: A national assessment, Studies in Water Policy and Management* (Boulder, CO and London, UK: Westview Press, 1985).

2.4. THE STATE OF ADAPTATION PLANNING

A meta-analysis of urban climate change adaptation planning in the U.S. was recently conducted by Hughes.¹²⁵ In conducting the literature review, she concluded that while awareness of climate change impacts and the imperative to adapt is high, and most adaptation is taking place at the local level, concrete adaptation actions are limited and success stories rely on a few leading communities. Hughes assessed the state of urban adaptation planning using 54 sources including the peer-reviewed literature, government reports, white papers, and reports published by non-governmental organizations, focusing on institutional support structures. Results demonstrated that adaptation planning is driven by a desire to reduce vulnerability and can create new governance coordination mechanisms. She concluded that to build capacity for adaptation the focus should be not just on city governments "but also on the complex horizontal and vertical networks that have arisen around such efforts" and points to a lack of attention on social vulnerability and non-climatic factors that affect vulnerability.¹²⁶

Older studies on local adaptaion include Bierbaum et al., who reviewed existing and planned adaptation activities of federal, tribal, state, and local gove.rnments as well as the private sector in the United States, using material

¹²⁵ Hughes, Sara. "A meta-analysis of urban climate change adaptation planning in the U.S." Urban Climate 14 (2015): 17-29, http://dx.doi.org/10.1016/j.uclim.2015.06.003.
¹²⁶ Hughes, 23.

for the 2013 U.S. National Climate Assessment, peer-reviewed and grey literature.¹²⁷ They categorized the activities by scale, sector, geographic location, and type of adaptation activity and analyzed these to understand the barriers and needs of stakeholders at different scales. They found most adaptation activities are occurring at local and regional levels and include land use planning, protection of infrastructure and ecosystems, regulations relating to design and construction, and emergency preparation, response and recovery. They concluded that, "Although substantial adaptation planning is occurring in various sectors, levels of government, and the private sector, few measures have been implemented and even fewer have been evaluated." ¹²⁸ Barriers to implementation included lack of funding, policy and institutional constraints, and difficulty in anticipating climate change. They found that because adaption fulfills other goals, such as disaster risk reduction, adaptation can be easily incorporated into existing decision-making processes. They say that adaptation has seldom been evaluated, because little has begun, and evaluation metrics do not yet exist.

Carmin et al. conducted a 40-question survey of 468 local governments that are members of ICLEI around the world, with the majority from the U.S. 79%

¹²⁷ Bierbaum, Rosina, Joel B. Smith, Arthur Lee, Maria Blair, Lynne Carter, F. Stuart Chapin III, Paul Fleming et al. "A comprehensive review of climate adaptation in the United States: more than before, but less than needed." *Mitigation and adaptation strategies for global change* 18.3 (2013): 361-406.
¹²⁸ Ibid., 361.

of cities reported environmental changes they attributed to climate change. Amongst their sample, 19% of the cities reported completing a climate assessment and 68% of cities reported pursuing adaptation planning. They found Latin American and Canadian cities (95% and 92%) had the highest rates of planning and the U.S. lowest with 59% of cities. The most significant adaptation impediments included funding, communicating the need for adaptation to elected officials and gaining commitment from national government for local adaptation challenges.

Preston, Westaway and Yuen looked at 57 adaptation plans from Australia, the U.K. and the U.S. and evaluated them against 19 planning processes identified from existing guidance documents for adaptation planning.¹²⁹ They say adaptation planning "[E]ffectively represents social and decision processes that facilitate the implementation of interventions to reduce vulnerability and/or take advantage of potential opportunities associated with climate variability and change."¹³⁰ Their results indicated that adaptation plans are underdeveloped. They suggest there are gaps in planning. 72% of identified options prescribed by plans reflected a bias toward low-risk capacity building over the delivery of specific actions. They concluded that there were

 ¹²⁹ Preston, Benjamin L., Richard M. Westaway, and Emma J. Yuen. "Climate adaptation planning in practice: an evaluation of adaptation plans from three developed nations." *Mitigation and adaptation strategies for global change* 16, no. 4 (2011): 407-438.
 ¹³⁰ Ibid., 413.

"significant deficiencies in climate change preparedness, even among those nations often assumed to have the greatest adaptive capacity."¹³¹

Shi, Chu and Debats recently published research on local adaptation barriers.¹³² They reviewed relative importance of constraints through a survey of 156 United States municipalities. They found, consistent with the literature, that cities taking action on climate adaptation were associated with greater local elected officials' commitment, higher municipal expenditures per capita, and an awareness of current evidence of climate change. They also found, that state law was not a significant predictor of action. They caveat, however, that there was a bias toward larger, more progressive cities, implying that state policy matters more for smaller, less capable and perhaps more conservative towns and villages.¹³³

Preston et al.'s findings comport with other evidence that cities have been prioritizing mitigation over adaptation. Hamin presents disconcerting evidence that is the scenario, or in some cases, implementing laws that benefit

¹³¹ Ibid., 407.

 ¹³² Shi, Linda, Eric Chu, and Jessica Debats. "Explaining Progress in Climate Adaptation Planning Across 156 US Municipalities." *Journal of the American Planning Association* (2015).
 ¹³³ Ibid.

both simultaneously.¹³⁴ She found that cities are prioritizing mitigation over adaptation in a sample of large global cities that included London, Melbourne, Chicago, Toronto, Halifax, Keene, New Hampshire, and Seattle (King County). Wheeler also found similarly. In a study of all of the climate change plans in all states with climate planning documents and all cities of over 500,000 that are members of the Cities for Climate Protection campaign, he concluded, "[m]ost plans do not address adaptation to a changing climate."¹³⁵ He reported than only six of 29 states and five of 35 cities mentioned the subject of adaptation in their climate planning documents, and nearly all "raised the subject simply as a topic for further research."136 Wheeler concluded that the first generation of climate plans mostly lacked the actions and political and institutional commitment needed to mitigate or adapt to climate change. Adaptation might be seen as expensive, exposing vulnerabilities, and perhaps has less political appeal. The reason for this bias is somewhat of a conundrum, since cities' adaptive actions are much more likely to immediately benefit their local populations than mitigation actions.

Engel and Orbach conjectured that the interest in mitigation might be due to other covert motivations, such as attracting green business, as economic

¹³⁴ Hamin, Elisabeth."Integrating Adaptation and Mitigation in Local Climate Change Planning," in *Climate Change and Land Policies*, eds. Gregory Ingram and Yu-Hung Hong (Cambridge, MA: The Lincoln Institute, 2011).

¹³⁵ Wheeler, "State and municipal climate change plans"¹³⁶ Ibid, 484.

development policy, or other political motivations.¹³⁷ It is also likely that this group of cities is prioritizing density because they have already existing infrastructure and little supply of new land. Mitigating climate change may be a convenient justification for policies they might pursue regardless.

Wheeler concluded that the first generation of climate plans were inadequate in their implementation.¹³⁸ Government officials Wheeler interviewed "said frankly that many...recommendations were not implemented, and frequently cited politics as a barrier..."¹³⁹ He concluded "most of these plans lack the strong actions and political and institutional commitment needed to mitigate emissions or adapt to climate change."¹⁴⁰

¹³⁷ Engel, Kirsten H. and Barak Y. Orbach, "Micro-motives and state and local climate change initiatives," *Harv. L. & Pol'y Rev.*, 2 (2008), 119-137.

¹³⁸ Wheeler, "State and municipal climate change plans,".", 481.

¹³⁹ Ibid., 487.

¹⁴⁰ Ibid., 488.

CHAPTER 3-LEGAL BACKGROUND

3.1. FEDERAL FRAMEWORK

The US federal government has a long and complex history of management of coastal areas within the federalist system and states and constitutional rights. Most notably, the Coastal Zone Management Act (CZMA), the National Flood Insurance Program (NFIP), and the Disaster Mitigation Act (DMA) affect coastal policy. Federal officials have reiterated the importance of local government and the limitation that federal policy has when not joined with cooperative local action. As John H. Dunnigan, Assistant Administrator for NOAA's National Ocean Service, testifying before the House of Representatives, said:

Managing growth and development in coastal areas was the most frequently identified challenge...Local governments were identified as primary partners for addressing growth pressures. Climate change was the top emerging issue.¹⁴¹

The federal government has taken steps toward incorporating climate change into coastal policy. Though most activities are in the form of commissions and studies, some laws mandate action. In 1990, Congress amended the CZMA and required that state plans anticipate and address sea level rise.¹⁴² The U.S.

¹⁴¹ J. H. Dunnigan, Written testimony of John H. Dunnigan, Assistant Administrator NOAA National Ocean Service, before the Committee on Natural Resources, U.S. House of Representatives, February 2, 2008.
 ¹⁴² 16 U.S.C. 1541

Army Corps of Engineers (USACE) issued a circular applying to all elements having Civil Works responsibilities.¹⁴³ Its purpose was to incorporate

direct and indirect physical effects of projected future sea-level change across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects.¹⁴⁴

The result of the policy is that "now impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs."¹⁴⁵

The Government Accountability Office (GAO) routinely monitors government operations it identifies as high risk, such as fraud and waste. In its February 2013 report (13-283), the GAO took the unprecedented step of adding climate change to its list of priorities regarding managing the federal government's fiscal risk, specifically citing the risk to infrastructure, such as defense installations; the National Flood Insurance Program; and the cost of FEMA emergency aid in response to natural disasters.¹⁴⁶

A follow-up GAO report identified the impacts of climate change on (1) roads and bridges, wastewater systems, and NASA centers; (2) the extent to which

 ¹⁴³ United States Army Corps of Engineers (USACE), Sea-level change considerations for civil works programs (EC 1165-2-212), (Washington, DC: U.S. Department of the Army, 2011).
 ¹⁴⁴ Ibid., 1.

¹⁴⁵ Ibid.

¹⁴⁶ U.S. Government Accountability Office (GAO), "13-283, Report to Congressional Committees, High Risk Series, an Update." Feb. 2013, 69, accessed March 30, 2016, <u>http://www.gao.gov/assets/660/652133.pdf</u>.

climate change is incorporated into infrastructure planning; (3) factors that enable some decision makers to implement adaptive measures; and (4) federal efforts to address local adaptation needs, as well as potential opportunities for improvement. Emphasizing the interdependent nature of governance levels, the report recommended that a federal entity work with agencies to identify and continually update climate information.¹⁴⁷

The Obama administration actively champions federal climate adaptation. In 2009, the Administration created the Interagency Climate Change Adaptation Task Force, which included representatives from more than 20 agencies, and signed an Executive Order, tasking it with developing a report to address how the federal government can prepare the nation to adapt to the impacts of climate change.¹⁴⁸ The report was released in 2011 and provides information on key areas, such as building resilience in local communities, safeguarding critical natural resources, such as freshwater, and providing accessible climate information and tools to help decision-makers manage climate risks. The executive order also required each agency to evaluate climate change risks and vulnerabilities and to prepare a climate change adaptation plan.¹⁴⁹

 ¹⁴⁷ U.S. Government Accountability Office (GAO), "Report to Congressional Requesters. Future Federal Adaptation Efforts Could Better Support Local Infrastructure Decision Makers," April, 2013, accessed March 30, 2016, <u>http://www.gao.gov/assets/660/653741.pdf</u>.
 ¹⁴⁸ Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," 2009.

¹⁴⁹ Exec. Order No. 13514, 3 C.F.R. 13514 (2009)

A November 2013 Executive Order requires that federal assets be maintained for climate preparedness and requires that federal agencies provide information, data and tools for climate change planning.¹⁵⁰ The executive order applies to federal assets only and does not directly involve regulation of property, which is the responsibility of the state and local governments.

A 2015 Executive Order requires federal agency heads, consistent with the provisions of EO 13653, to ensure that agency operations and facilities prepare for climate change by identifying and addressing its impacts on energy, communication and transportation demands, as well as on operational preparedness.¹⁵¹ It also requires agencies to calculate the potential cost and risks to their mission if they do not account for such climate information.

3.2. THE COASTAL ZONE MANAGEMENT ACT (CZMA)

The 1972 Coastal Zone Management Act (CZMA),¹⁵² reauthorized a number of times, "provides a proven basis for protecting, restoring, and responsibly developing the nation's important and diverse coastal communities and

¹⁵⁰ Exec. Order No. 13653, 3 C.F.R. 13653 (2015)

¹⁵¹ Ibid.

¹⁵² CZMA (Coastal Zone Management Act), 2009, 16 U.S.C. 1540 et seq.

resources."¹⁵³ The act's objectives include protection of public access, promotion of seaports and revitalization of waterfronts.¹⁵⁴ Although participation is voluntary, the CZMA operates through state legislation and plans in the 35 coastal states and territories covering all of the 95,331 miles of American shoreline.¹⁵⁵

The federal government recognized the significance of coastal climate change as early as 1990; amendments to the law required state CZMA plans to anticipate and address sea level rise.¹⁵⁶ Various states implement CZMA differently. New York State law authorizes local communities to prepare comprehensive plans for waterfront issues, called the Local Waterfront Revitalization Plan (LWRP), which is an enforceable set of policies.¹⁵⁷ Required under state law for any town with an adopted LWRP, the Waterfront Consistency Review process reviews actions in the coastal area for consistency with the LWRP and coordinates review with the NYS Department of State regarding federal and state actions. All projects must undergo Waterfront

¹⁵³ National Oceanic and Atmospheric Administration (NOAA), 2007. Coastal Zone Management Program Strategic Plan: Improving Management of the Nation's Coastal Areas, accessed March 7, 2014: http://coastalmanagement.noaa.gov/success/ media/CZM_stratplan_final_FY07.pdf.

¹⁵⁴ Environmental Protection Agency (EPA), "National CZM Effectiveness Study, Coastlines," 2007, accessed February 7, 2014, www.epa.gov/owow/estuaries/coastlines/ summer97/csm.html.

¹⁵⁵ U.S. Government Accountability Office (GAO) 2008. Coastal Zone Management: Measuring Program's Effectiveness Continues to Be a Challenge. Report to the subcommittee on Oceans, Atmosphere, Fisheries and Coast Guard, Committee on Commerce, Science, and Transportation.

¹⁵⁶ Coastal Zone Act Reauthorization Act of 1990, P.L. No 101-508, 16 U.S.C.A. Sec. 1453. ¹⁵⁷ State of New York, Local Waterfront Revitalization Program. http://www.dos.ny.gov/ communitieswaterfronts/WFRevitalization/LWRP.html (accessed on 03.07.14.).

Consistency Review except for specifically designated exempt actions. This type of multi-layer regulation shows how federal, state and localities can work together to achieve adaptation and resiliency goals. The flexibility inherent in the law allows for variation in local approaches given community needs.

The Coastal State Climate Change Planning Act was a bill introduced in the U.S. House of Representatives first in the 110th Congress in 2008,¹⁵⁸ and subsequently in the 111th,¹⁵⁹ 112th¹⁶⁰, and 113th congresses.¹⁶¹ Most recently, Rep. Louis Capps [D-CA] reintroduced it on Mar. 04, 2015.¹⁶² It was referred to the Subcommittee on Energy and Mineral Resources on Mar. 23, 2015, and has not been acted upon since then. The act was to provide funding and technical assistance for state planning that addressed climate change adaptation under the CZMA Section 306 approved management plans.¹⁶³ The bill was reintroduced in 2009 as H.R. 1905. The bill would have amended the Coastal Zone Management Act of 1972 to establish a coastal climate change adaptation program to provide funding to states. The bill had expressly included provisions for technical training and assistance to local governments "to increase awareness of science, management, and technology information related to climate change adaptation strategies."¹⁶⁴

¹⁵⁸ H.R. 5453, 110th Cong. (2007-2008).

¹⁵⁹ H.R. 1905, 111th Cong. (2009-2010).

¹⁶⁰ H.R. 4314, 112th Cong. (2011-2012)

¹⁶¹ H.R.764, 113th Cong. (2013-2014).

 $^{^{162}}$ H.R. 1276, 114th Cong (2015-2016).

¹⁶³ H.R. 5453, 110th Cong. (2007-2008).

¹⁶⁴ H.R. 5453 (d)(3)(E) (2008).

3.3. DISASTER MITIGATION ACT

The Disaster Mitigation Act of 2000 (DMA) introduced planning requirements to qualify for pre- and post- disaster assistance from the federal government. The DMA is intended to "alleviate the suffering and damage that results from disasters by...encouraging hazard mitigation measures."¹⁶⁵

Hazard mitigation plans (HMPs) must be completed by both the state and local governments. These governments must review and update their plans every five years in order to be eligible to continue to receive funding. Many localities are opting to participate in multi-jurisdiction plans. The process requires input from the public, business, non-profit organizations, universities, and other government agencies. Even though the plans can be jointly drafted, each jurisdiction must separately adopt the plan.¹⁶⁶ In order to assure the plans are of a certain quality, The Federal Emergency Management Agency (FEMA) must approve the plans before the jurisdiction is eligible for federal funds.

One of the main objectives of the DMA planning rules is to ensure that the principles of hazard mitigation are incorporated into land use plans. To that end, the hazard mitigation plans must include information about land use and development trends. In addition, the act also requires the hazard plan to be

¹⁶⁵ Disaster Mitigation Act of 2000, (42 U.S.C. § 5121(b))

¹⁶⁶ 44 C.F.R. § 201.6.a(4)

incorporated into "other planning mechanisms such as comprehensive or capital improvement plans..."¹⁶⁷ Although the DMA does not require it, more and more communities are including climate charge and sea level rise as a hazard to be analyzed in their plans.

Guilford, Connecticut and Barnstable, Massachusetts are using climate change information to amend both their hazard mitigation and comprehensive plans, creating a nexus between the two. Sea level rise was addressed as a separate hazard in the Barnstable's Multi-Hazard Mitigation Plan. The plan specifically considers two mitigation actions in relation to sea level rise.

The DMA has already made a difference in communities' climate preparedness by introducing requirements for rigorous hazard planning across the country. Local governments can take further advantage of the funding provided to enhance their climate and disaster resilience together as well as tie in local land use and building code regulations.

3.4. THE NATIONAL FLOOD INSURANCE PROGRAM AND COMMUNITY RATING SYSTEM

Since the launch of the National Flood Insurance Program (NFIP) in the early 1970's, about \$24 billion in losses have been paid to insurance policyholders in coastal floodplains. The NFIP is often criticized as incentivizing poor

^{167 44} C.F.R. § 201.6

development decisions on the coast, despite that according to FEMA, the NFIP "was created by Congress to mitigate future flood losses...through sound, community-enforced building and zoning ordinances and to provide access to affordable, federally backed flood insurance protection for property owners."¹⁶⁸ The NFIP was intended to provide an insurance alternative to the previous disaster management and hard-infrastructure based systems, attempting to recover some of the costs of recovery and to shift awareness of the risks toward communities and landowners.

Conservation and education regarding better coastal planning were a component of the program at its creation, but they have largely failed to have that impact. According to FEMA, NFIP was intended to mitigate future flood losses through community-enforced building and zoning ordinances and to provide affordable flood insurance for homeowners. NFIP was conceived of providing an alternative in the form of insurance to the previous disaster management and hard-infrastructure based responses. Eligibility for subsidized insurance is predicated upon a community adopting and enforcing a local floodplain management ordinance to reduce flood risks. In addition to the minimum standards, FEMA administers a voluntary program that incentivizes stricter regulations called the Community Rating System (CRS). According to FEMA, the CRS purpose is to 1) reduce flood damage to insurable

¹⁶⁸ Federal Emergency Management Agency (FEMA), 2011. Answers to Questions about the National Flood Insurance Program. FEMA F-084.

property, and 2) strengthen and support the insurance aspects of the NFIP, and 3) encourage a comprehensive approach to floodplain management.¹⁶⁹ Homeowners in each community become eligible for discounts corresponding to the rating level the municipality scores. Discounts can range from 5% to up to 45%.

The CRS contains a number of provisions that give credit to communities for addressing climate change or sea level rise in their flood regulations. Sec. 322.c provides CRS credits "for communities that provide information about areas (not mapped on the FIRM) that are predicted to be susceptible to flooding in the future because of climate change or sea level rise."¹⁷⁰ The program also sets certain thresholds for communities to attain status at a certain class. To achieve Class 4 or better status, a community must demonstrate that it has programs that minimize increases in future flooding, and to achieve a Class 1 status, communities must use regulatory flood elevations in the V and coastal A zone that take into account sea level rise and future conditions. Credits are available when the regulatory map is based on future conditions, including climate change or sea level rise,¹⁷¹ as well as if sellers of flood-prone property disclose potential flooding due to climate change or sea level rise.¹⁷²

¹⁶⁹ Ibid.

¹⁷⁰ FEMA, Community Rating System Manual, Sec. 322.c

¹⁷¹ CRS manual, Sec. 412.d

¹⁷² Ibid. Sec. 342.d
While these predicate requirements cannot be dismissed as totally ineffectual, the NFIP on balance has been found to have harmful effects on coastal sustainability. For instance, Bagstad, Stapleton and D'Agostino studied the impact of flood insurance on economic behavior and concluded that the NFIP encourages development and rebuilding in flood-prone areas because it pays multiple times for the same property and does not raise rates with each additional claim.¹⁷³ "When disaster strikes, developers are able to buy up large amounts of land at steeply discounted rates, knowing they can rebuild and sell that property at rates that do not reflect the site's propensity for flooding."¹⁷⁴ In economic terms, the NFIP causes problems with information asymmetry and moral hazard, since many people do not maintain coverage, and it potentially encourages development in ecologically sensitive areas.

Numerous efforts to reform the NFIP have led to resistance and ultimately curtailment of changes actually passed into law. The 2004 Flood Insurance Reform Act attempted to tackle the challenge of repetitive loss properties, which represent some of the most significant costs for the NFIP, but only had a negligible impact on reducing risk. In 2012, Congress passed the Biggert-Waters Act, which was to reform the nearly bankrupt flood insurance program,

¹⁷³ Bagstad, Kenneth, Kevin Stapleton, and John R. D'Agostino, "Taxes, subsidies, and insurance as drivers of United States coastal development," *Ecological Economics* 63 (2007): 285-298.

¹⁷⁴ Ibid., 288.

ending federal subsidies for insuring buildings in flood-prone coastal areas over time by allowing premiums to rise to actuarial rates.¹⁷⁵ It included a provision to eliminate grandfathering for older homes that did not meet the newest codes.¹⁷⁶ The bill passed with no debate and was popular across the political spectrum, from fiscal conservatives to environmentalists. However, it resulted in outrage from homeowners whose flood insurance premiums increased up to ten times previous amounts.¹⁷⁷ The result was Congress passing the Homeowner Flood Insurance Affordability Act (HFIA), repealing most of the provisions of the Biggert-Waters Act.¹⁷⁸ The HFIA reinstated the NFIP grandfathering, preserved discounted premiums for sold properties, and reduced the yearly premium increases.¹⁷⁹

Buyouts have been a key component of reducing risk in floodplains and contributing to a new conception of the coastal commons since FEMA initiated its current property-acquisition policy in 1993. The federal government has

¹⁷⁵ Pub. L. No. 112-141 §§ §§ 100201–100261, 126 Stat. 405, 916–79 (2012)
¹⁷⁶ Nance, Earthea, "Exploring the impacts of flood insurance reform on vulnerable communities," *International Journal of Disaster Risk Reduction* 13 (2015): 20-36.
¹⁷⁷ Ferraro, Thomas. "U.S. Senate Passes Bill to Delay Hikes in Flood Insurance Rates," *Reuters*, January 30, 2014, accessed March 30, 2016, http://www.reuters.com/article/2014/01/30/us-usainsurance-flooding-

idUSBREA0T1WK20140130.

¹⁷⁸ Pub. L. No. 113-89, 128 Stat. 1020 (2014).

¹⁷⁹ Omri Ben-Shahar and Kyle D. Logue, "Under the Weather: Government Insurance and the Regulation of Climate Risks," University of Chicago Coase-Sandor Institute for Law & Economics Research Paper, 714 (2015), accessed March 30, 2016, http://chicagounhound.uchicago.edu/cgi/viewcontent.cgi?article=2394&context=law_and_eco

 $http://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=2394 \& context=law_and_economics.$

purchased over 37,000 individual properties worth more than \$2 billion.¹⁸⁰ Federal law requires the state or local government raze the buildings and maintain the property as public open space.¹⁸¹ The majority of these buyouts were actually located in riverine floodplains, and Missouri had the highest number of purchases, which reflects the focus of FEMA after the Great Midwest Floods in 1993.¹⁸² Poelefka points out, however, that "the scale of liabilities growing along our nation's coasts dwarfs those figures."¹⁸³ About \$24 billion in losses were paid to NFIP policyholders in the coastal floodplain, and 9 of the 10 most destructive flood events since 1999 were coastal.¹⁸⁴

There are a number of specific programs that the federal government maintains under which buyouts can be funded for pre- and post- disaster purposes. The Hazard Mitigation Grant Program (HMGP), which was established in 1988 under the Stafford Act, focuses on post-disaster buyouts, and a number of other programs under the Hazard Mitigation Assistance (HMA) program focus on pre-disaster acquisitions. The latter includes the Severe Repetitive Loss program, Repetitive Flood Claims program, Pre-

¹⁸⁰ Lieb, David A. and Jim Salter, "AP News Break: FEMA flood buyouts top \$2B since 1993," Yahoo! News, July 12, 2011, accessed March 30, 2016, <u>http://news.yahoo.com/apnewsbreak-femaf lood-buyouts-top-2b-since-1993-185604826.html</u>.

¹⁸¹ 44 C.F.R. § 80.19(a).

¹⁸² Shiva, Polefka. "Moving Out of Harm's Way," *Center for American Progress*, December 12, 2013, accessed March 30, 2016, http://www.americanprogress.org/wp-content/uploads/2013/12/FloodBuyouts-2.pdf.
¹⁸³ Ibid., 8.

¹⁸⁴ Ibid.

Disaster Mitigation Program, and Flood Mitigation Assistance Program.¹⁸⁵ A number of restrictions must be met for a property to be eligible for acquisition under HMA, including that the property owner must be a willing seller, the property must contain an at-risk structure, the acquired property cannot contain contaminated materials, and the property cannot be subdivided.¹⁸⁶

3.5. COASTAL BARRIER RESOURCE ACT (CBRA)

The Coastal Barrier Resources Act set a new precedent by prohibiting the federal government from any financial support of development in designated undeveloped coastal barrier islands, including the prohibition of sale of NFIP flood insurance for all new construction, as well as removal of subsidies for water and sewer infrastructure.¹⁸⁷ Salvesen concluded the act has made development more difficult and expensive, and has reduced wasteful federal spending, but that the act is not sufficient to prohibit development, since the ultimate authority on development decisions rests with state and local governments.¹⁸⁸ He concluded that act may not have had a significant effect on coastal barriers where the real estate market is strong, but it likely delayed or prevented growth in the vast majority of locations that remain undeveloped.¹⁸⁹

¹⁸⁵ FEMA, Hazard Mitigation Assistance Unified Guidance (2010).

¹⁸⁶ Lewis, David A. "The Relocation of Development from Coastal Hazards through Publicly Funded Acquisition Programs: Examples and Lessons from the Gulf Coast," *Sea Grant L. and Pol'y J.* 5 (2012): 116.

 $^{^{187}}$ The Coastal Barrier Resources Act (CBRA) 1982, 16 U.S.C. 3510 et seq.

¹⁸⁸ Salvesen, David. "The Coastal Barrier Resources Act: has it discouraged coastal development?" *Coastal Management* 33, no. 2 (2005): 181-195.
¹⁸⁹ Ibid.

This suggests that multi-lateral programs, such as the CRS and CZMA, are likely more effective than federal action alone.

3.6. STATE FRAMEWORK

States have extensive regulations concerning coastal land use, and many are beginning to implement climate change adaptation in their regulations. All ten states in the North Atlantic have taken some action to adapt to climate change, but the degree to which planning has been formalized and implemented in law varies greatly. Eight of the ten states have prepared a formal climate adaptation plan of some type, with only New Jersey and Delaware behind. Maine, Rhode Island, Massachusetts and Connecticut are perhaps the farthest ahead, having adopted law that requires local governments to consider climate change in land use decisions. In general, the Mid-Atlantic states have made less progress, although Delaware has made particular strides toward adaptation.

Burby and Dalton showed that differences in state law have a significant impact on the outcomes of natural hazard planning at the local level, and that that states with comprehensive planning requirements had significantly reduced losses from natural disasters.¹⁹⁰ Maine, Rhode Island, Massachusetts

¹⁹⁰ Burby, Raymond J. and Linda C. Dalton. "Plans can matter! The role of land use and state planning mandates on limiting development of hazardous areas." *Public Adm. Rev.* 54 No. 3 (1994), 229-238.

and Connecticut are perhaps the farthest ahead, having adopted law that requires local governments to consider climate change in land use decisions. In general, the Mid-Atlantic states have made less progress, although Delaware has made particular strides toward adaptation.

3.6.1. Maine

The State of Maine has been regulating its coastal region and protecting against erosion and sea level rise for over thirty years, through the Natural Resources Protection Act Sand Dune Rules and Shoreland Zoning system. These regulations now require consideration of shoreline changes based on two feet of sea level rise by 2100. The law prohibits permitting of a project, "if, within 100 years, the property may reasonably expected to be eroded as a result in changes in the shoreline...if it is likely to be severely damaged after allowing for a two foot rise in sea level over 100 years."¹⁹¹ In addition, it limits the size of structures to 2,500 square feet unless the applicant can demonstrate the site will remain stable after allowing for a two-foot rise in sea level over 100 years.

Maine statutes state:

The extent to which sea level will change in the future is uncertain. However, the department anticipates that sea level will rise approximately two feet in the next 100 years. Under any scenario of increasing sea level, the extensive development of sand dune areas and

¹⁹¹ 38 M.R.S. Ch. 355.5 (C).

¹⁹² Ibid. § 5(C), 5(D)

the construction of structures increase the risk of harm, to both the coastal sand dune system and the structures themselves. 193

The law further reads that in order to protect coastal sand dune systems, the state agencies will "evaluate proposed developments with consideration given to future sea level rise and will impose restrictions on the density and location of development and on the size of structures."¹⁹⁴ In defining the FEMA flood zones, Maine law states:

Note: AO-Zones involve more sand transport and hazard to property than other A-Zones. FEMA recommends Coastal AO-Zones be treated as V-Zones for design and risk analysis. In terms of sand transport and flooding, AO-Zones act more like V-Zones, with only a foot of sea-level rise (or lowering of the beach and dune profile) an AO-Zone will become a V-Zone.¹⁹⁵

The statutes also define an "erosion hazard area" as:

any portion of the coastal sand dune system that can reasonably be expected to become part of a coastal wetland in the next 100 years due to cumulative and collective changes in the shoreline from: (1) Historical long-term erosion; (2) Short-term erosion resulting from a 100-year storm; or (3) Flooding in a 100-year storm after a two-foot rise in sea level.¹⁹⁶

The Maine Growth Management Act also requires that coastal municipalities address state coastal management policies in their comprehensive plans, which includes, amongst other goals, "to discourage growth and new

¹⁹³ Ibid. § 1

¹⁹⁴ Ibid.

¹⁹⁵ Ibid. § 3

¹⁹⁶ Ibid. Ch. 305, § 16 (C) F.

development in coastal areas where, because of coastal storms, flooding, landslides or sea-level rise, it is hazardous to human health and safety."¹⁹⁷

3.6.2. New Hampshire

New Hampshire has only a single reference to sea level rise in all of its statutes. That reference pertains to be scoring system for evaluating applications for coastal program grants. The statute requires applications for grants to be scored based on anticipated benefits to: Restoration of coastal habitats; Water quality and stormwater management; Land conservation; Climate change adaptation and coastal hazards; or (5) Ocean and estuarine resources.¹⁹⁸

It further states that specific types of projects that directly address one of the five focus areas shall qualify as high priority projects and receive additional points. For the climate change adaptation and coastal hazards criteria, it includes projects that

promote climate change adaptation and mitigation of coastal hazards by:

- a. Planning and modeling for sea level rise;
- b. Implementing actions to protect coastal infrastructure and resources; or
- c. Promulgating local regulations¹⁹⁹

¹⁹⁷ 38 M.R.S. §1801(d.)

¹⁹⁸ N.H. Code Admin. R. Env-Wq 2006.03(a)

¹⁹⁹ Ibid. 2006.03(c)(3)(a)

New Hampshire's implementation of the federal CZMA, the Shoreland Protection Act was enacted in 2006.²⁰⁰ Many New Hampshire towns do not have zoning, and the state has no requirements that communities plan or zone. The result is that in those communities, "the Shoreland Protection Act is all that may stand between the river and inappropriate land uses..."²⁰¹

New Hampshire state law requires municipalities that adopt zoning to also have a corresponding master plan. Municipalities are authorized to include natural hazard elements in their master plans. New Hampshire also passed legislation to establish the Coastal Risk and Hazards Commission in 2013, "to help coastal communities and the state prepare for projected sea level rise and other coastal and coastal watershed hazards." ²⁰² The commission is to recommend legislation, rules and other actions to prepare for sea level rise and other coastal hazards such as increased storms, flooding and runoff, but to date, no law has been enacted.

3.6.3. Massachusetts

Massachusetts has taken a number of legal steps to ensure the commonwealth is taking adequate action to adapt to climate change. Massachusetts is

²⁰⁰ RSA 483-B

²⁰¹ Connecticut River Joint Commission. "New Hampshire's Shoreland Protection Act - RSA 483-B," Mar. 29, 2006.

http://des.nh.gov/organization/divisions/water/wetlands/cspa/documents/crjc_comments.pdf ²⁰² New Hampshire Coastal Risk and Hazards Commission, "About," accessed October 27, 2015, <u>http://nhcrhc.stormsmart.org/sample-page/</u>.

currently the only U.S. state that has amended its "little NEPA" law to mandate consideration of climate change.²⁰³ In 2009, the Massachusetts Environmental Policy Act (MEPA) was amended to include the following language:

In considering and issuing permits, licenses, and other administrative approvals and decisions, the respective agency, department, board, commission or authority shall also consider reasonably foreseeable climate change impacts, including additional greenhouse gas emissions, and effects, such as predicted sea level rise.²⁰⁴

The draft MEPA guidance specifies EISs should assess sea level rise, coastal flooding, and storm surge.²⁰⁵

Massachusetts statewide building code also requires new non-water dependent buildings in a floodplain to be designed to withstand projected sea level rise, based on historic rates in New England.²⁰⁶ The state's Office of Coastal Zone Management Policy Guide also contains numerous provisions relating to sea level rise. It states that amongst CZM's intent including preventing threats to public safety and the environment, allowing physical processes to continue

²⁰³ Jessica Wentz, "Assessing the Impacts of Climate Change on the Built Environment under NEPA and State EIA Laws: A Survey of Current Practices and Recommendations for Model Protocols," Columbia Law School, Sabin Center for Climate Change Law (2015), accessed March 30, 2016, <u>http://web.law.columbia.edu/sites/default/files/microsites/climatechange/assessing the impacts of climate change on the built environment - final.pdf</u>. ²⁰⁴ Mass. Gen. Laws Ch. 30, § 61, amended by Massachusetts Global Warming Solutions Act (GWSA), Ch. 298 of the Acts of 2008, § § 7. See also Mass. Code Regs. § 11.12(5)(a).

²⁰⁵ Commonwealth of Massachusetts, Draft MEPA Climate Change Adaptation and Resiliency Policy (2014).

²⁰⁶ 310 Code of Mass. Regs. 9.37(2)(b)(2)

while promoting appropriately sited coastal development, limiting expenditures in high hazard areas, and to prioritize public expenditures for acquisition and relocation of structures out of hazardous coastal areas, which are defined as those areas susceptible to storm surge and waves, flooding, erosion, and relative sea level rise.²⁰⁷

The enforceable coastal hazards policy states:

The need for resource areas (salt marshes, dunes, beaches, etc.) to migrate landward in response to relative sea level rise should be addressed through the design, placement, and elevation of structures, as well as for other activities in the coastal floodplain. Structures should be placed as far landward as feasible to avoid or at least minimize potential coastal hazards impacts and to allow landward migration of resource areas; elevation of structures is another means of minimizing unavoidable impacts.²⁰⁸

The state is also moving ahead with its climate preparedness initiative. In January 2014, Governor Deval Patrick announced a \$50 million climate preparedness initiative which includes a \$40 million municipal resilience grant program for towns and cities to invest in clean energy technology that reduce climate-induced electricity disruptions as well as \$10 million for coastal infrastructure and \$1 million in grants for communities to address sea level

²⁰⁷ Commonwealth of Massachusetts Office of Coastal Zone Management, Draft Policy Guide (2011), 19.

²⁰⁸ Commonwealth of Mass., Office of Coastal Zone Management, Draft Policy Guide (October, 2011), 19-20, accessed March 30, 2016, <u>http://www.mass.gov/eea/docs/czm/fcr-regs/czm-policy-guide-october2011.pdf</u>.

rise.²⁰⁹ Massachusetts' Coastal Zone Management Office StormSmart Coasts program also provides information and strategies to deal with sea level rise as well as distributes grant funding related to coastal resilience.²¹⁰

3.6.4. Rhode Island

Rhode Island was the first state in the North Atlantic region to pass a law mandating the consideration of climate change. In 2006, Rhode Island's Building Code Commission amended the state building code to consider the impacts of sea-level rise when developing new regulations. The commission later required all new development in certain coastal zones to be built one foot above base flood elevation. In 2008, the Rhode Island Coastal Resources Management Program (CRMP) adopted a climate change policy to plan for sea level rise in siting, design, and implementation of private and public coastal development projects.²¹¹

Rhode Island took the most aggressive step to combat sea level rise in 2011 when it amended the Rhode Island Comprehensive Planning and Land Use Act requiring local comprehensive plans to incorporate natural hazards,

²⁰⁹ Irons, Meghan E. "Patrick unveils \$50m plan on climate change." *The Boston Globe*, Jan. 14, 2014.

²¹⁰ Commonwealth of Mass. Energy and Environmental Affairs, "Coastal Resilience Grant Program." Accessed April 1, 201, http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/grants/

²¹¹ R.I. C.R.M.P. 2008, Sec. 145

including flooding, storm damage and SLR.²¹² The law requires goals, policies and implementation techniques be identified to minimize the impact of hazards on lives, infrastructure and property.²¹³

3.6.5. Connecticut

Connecticut passed a law (An Act Concerning The Coastal Management Act

and Shoreline Flood and Erosion Control Structures) in 2012, that mandated

that sea level rise be incorporated into the Connecticut Coastal Management

Act's general goals and policies.²¹⁴ The act defined sea level rise as:

the arithmetic mean of the most recent equivalent per decade rise in the surface level of the tidal and coastal waters of the state, as documented for an annual, decadal or centenary period, at any sites specified in the state in National Oceanic and Atmospheric online or printed publications.²¹⁵

The amendment to the act's goals include:

To consider in the planning process the potential impact of a rise in sea level, coastal flooding and erosion patterns on coastal development so as to minimize damage to and destruction of life and property and [reduce] minimize the necessity of public expenditure and shoreline armoring to protect future new development from such hazards.²¹⁶

This provision specifically requires sea level rise to be considered in planning

processes, but excludes sea level rise from being considered in regulations by

state and local government.²¹⁷

²¹² R.I. Gen. Laws, Ch. 45-22.2-6

²¹³ Ibid.

 $^{^{214}}$ Conn. Public Act 12-102, Conn Gen. Stat. 22a-90-112

²¹⁵ Conn. Gen. Stat. 22a-93 (19)

²¹⁶ Conn. Gen. Stat. 22a-92(A)(5)

²¹⁷ Connecticut Coastal Omnibus Bill, 2012 CT SB 376, Public Act 12-101

The law specifically requires revisions to the state's plan of development and conservation

take into consideration risks associated with increased coastal erosion, depending on site topography, caused by a rise in sea level...2) identify the impacts of such increased erosion on infrastructure and natural resources, and (3) make recommendations for the siting of future infrastructure and property development to minimize the use of areas prone to such erosion.²¹⁸

Previously enacted goals of the act include encouraging public access to the coastal waters by development and expansion of state-owned recreational facilities,²¹⁹ to conduct and sponsor research to base coastal land and water use decisions,²²⁰ and to coordinate activities of the state to ensure maximum protection of natural resources consistent with the state plan for conservation and development.²²¹ The act also reiterates the state's commitment to the constitutional protection of private property owners and emphasizes the use of existing laws and planning processes to manage Connecticut's coast. The law also contains a number of specific policies established for federal, state and municipal agencies concerning development, facilities and uses within the coastal area that can together be seen as a type of coastal smart growth legislation.

²¹⁸ Public Act No. 12-101, Sec. 9 (H)

²¹⁹ Conn. Gen. Stat. Sec. 22a-92(A)(6)

²²⁰ Ibid. 22a-92(A)(7)

²²¹ Ibid. 22a-92(A)(8)

The law requires that sewer and water lines should be located to

encourage concentrated development in areas which are suitable for development, and to disapprove extension of sewer and water services into developed and undeveloped beaches, barrier beaches and tidal wetlands except that, when necessary to abate existing sources of pollution, sewers that will accommodate existing uses with limited excess capacity may be used.²²²

It also prohibits new fuel and chemical storage facilities "which can reasonably be located inland" and requires new tanks to abut existing ones, be located in urban industrial areas, and be adequately protected against floods and spills." ²²³ The law also requires rehabilitation or upgrading of existing transportation facilities, as opposed to construction of new facilities.²²⁴

Another 2012 amendment of significant interest is the addition of a "deadline" of January 1, 1995, for the provision that allows structural protection of coastal property. The section reads that agencies shall reduce hazards to life and property and promote nonstructural flood and erosion solutions "except in those instances where structural solutions prove unavoidable and necessary to protect [existing] inhabited structures constructed as of January 1, 1995."²²⁵ The law further explains:

structural solutions are permissible when necessary and unavoidable for the protection of infrastructural facilities, water-dependent uses, or [existing] inhabited structures constructed as of January 1, 1995, cemetery or burial grounds, and where there is no feasible, less

²²² Ibid. 22a-92(b)(1)B

²²³ Ibid. 22a-92(b)(1)E

²²⁴ Ibid. 22a-92(b)(1)F

²²⁵ Ibid. 22a-92(b)(2)F

environmentally damaging alternative and where all reasonable mitigation measures and techniques have been provided to minimize adverse environmental impacts.²²⁶

The law defines feasible, less environmentally damaging alternatives to include relocation of a structure to a landward location, elevation of the structure, restoration or creation of a dune, or living shoreline techniques.²²⁷

3.6.6. New York

New York State also passed landmark legislation to respond to climate change in the wake of Superstorm Sandy. In March 2015, the legislature passed the Community Risk and Resiliency Act, which requires state agencies to consider climate risks in permitting, funding and regulatory decisions.²²⁸ The act also requires state agencies to prepare model local laws to provide guidance for local governments, and establishes that the state shall establish science-based sea level rise projections by January 2016. ²²⁹ The law is weaker than Rhode Island's because no formal regulations relating to coastal land or planning were adopted.

The law requires state agencies to establish science-based sea level rise projections and to update the data every five years. The law requires consideration of sea level rise, storm surge and flooding in a number of state

²²⁶ Ibid. 22a-92(b)(2)J

²²⁷ Ibid. 22a092(e)

²²⁸ NY Enviro. Conservation L. § 3-0319 (CRRA)

²²⁹ Ibid.

policies and programs, including facility siting, permitting and funding. The law amends the Environmental Conservation Law, Agriculture and Markets Law, and Public Health Law to require applicants for permits or funding in a number of state programs to demonstrate that future physical climate risk due to sea-level rise, storm surge and flooding have been considered. In addition, the law requires agencies to develop additional-guidance 'on the use of resiliency measures that utilize natural resources and natural processes to reduce risk.²³⁰

The act amends provisions of state law to require state agencies to consider climate change risk when issuing facilitating siting permits for hazardous waste transportation, storage and distribution facility siting;²³¹ petroleum bulk storage siting;²³² and hazardous substance bulk storage siting.²³³ For example, when the state Department of Environmental Conservation promulgates rules for establishing standards for existing and new petroleum bulk storage facilities regarding design, construction and maintenance, it must consider future physical risk due to sea level rise, storm surges or flooding.²³⁴

²³⁰ New York State Assembly - Bill A06558. Memorandum in Support of Legislation (April 9, 2013).

²³¹ CRRA Sec. 4

²³² CRRA Sec. 9

 $^{^{\}rm 233}$ CRRA Sec. 5

²³⁴ N.Y. C.L.S. Enviro. Cons. L. Sec. 17-1015 (2015)

The law also requires state agencies to consider climate change when issuing permits such as for oil and natural gas wells,²³⁵ protection of waters, sewerage service, liquefied natural gas and liquefied propane facility permits, mined land reclamation permits, freshwater wetlands and tidal wetlands permits, and coastal erosion hazard areas.²³⁶

The law also applies to many New York State funding programs, including the Water Pollution Control Revolving Fund,²³⁷ the Drinking Water Revolving Fund,²³⁸ Open space acquistion decisions and open space project operations and maintenance agreements; ²³⁹ landfill closure assistance; ²⁴⁰ coastal rehabilitation project assistance;²⁴¹ the local waterfront revitalization program operated by the Department of State; ²⁴² and agricultural and farmland protection, operated by the Department of Agriculture and Markets.²⁴³

For example, CRRA requires municipalities that operate landfills only apply for state assistance upon showing specific provisions, including a closure investigation report which complies with regulations, "including a

²⁴¹ CRRA Sec. 11

²³⁵ CRRA Sec. 14-a

²³⁶ CRRA Sec. 15

²³⁷ CRRA Sec. 3

²³⁸ CRRA Sec. 13

 ²³⁹ CRRA Sec. 6 and 7
 ²⁴⁰ CRRA Sec. 8

²⁴² CRRA Sec. 10

²⁴³ CRRA Sec. 12

demonstration that future physical climate risk due to sea level rise, and/or storm surges and/or flooding, based on available data predicting the likelihood of extreme weather events, including hazard risk analysis data if applicable, has been considered."²⁴⁴

New York State's response to Sandy, however, is perhaps its ultimate achievement demonstrating a new, integrated approach to coastal planning. The state funded and required communities devastated by Hurricanes Irene, Lee and Sandy to engage in a community-based recovery planning process and consider climate change in the plans. 65 plans in communities throughout the state were drafted and over 1400 individual recovery projects were proposed. New York State's guidance for communities emphasized the importance of generating and enhancing the co-benefits of resilience, sustainability and economic development, as well as the goal of long-term, locally-led resilience.

New York State is also a jurisdiction with a "little NEPA" and a number of policies have directed agencies to incorporate climate change analysis into the preparation of environmental impact statements. The New York State Department of Environmental Conservation (DEC) now must "identify potential adverse impacts from climate change" on all DEC programs, "incorporate climate change adaptation strategies into applicable DEC

²⁴⁴ N.Y. C.L.S. Enviro. Cons. L. Sec. 54-0503 (2015)

programs, actions and activities" and "use the best available scientific information of environmental conditions resulting from the impacts of climate change."²⁴⁵ New York City also has its own City Environmental Quality Review Act, and its technical manual also requires consideration of climate change. It states:

...depending on a project's sensitivity, location, and useful life, it may be appropriate to provide a qualitative discussion of the potential effects of climate change on a proposed project in environmental review. Such a discussion should focus on early integration of climate change considerations into the project and may include proposals to increase climate resilience and adaptive management strategies to allow for uncertainties in environmental conditions resulting from climate change.²⁴⁶

New York State's comprehensive coastal management program is called the Coastal Erosion Hazard Areas Law (CEHA), ²⁴⁷ and it requires the state map erosion hazard areas and adopt regulations to control development. ²⁴⁸ The regulations require special permits for construction in the hazard area. Because the hazard areas are dependent on actual erosion rates, they have the potential to enforce a sea level rise retreat policy. In practice, the maps defining these areas have been fixed since the 1980s. The state is, however, currently

²⁴⁵ New York State Department of Environmental Conservation (DEC), Commissioner's Policy – Climate Change and DEC Action (2010), accessed http://www.dec.ny.gov/regulations/65034.html.

²⁴⁶ City of New York, Mayor's Office of Environmental Coordination, City Environmental Quality Review (CEQR) Technical Manual, Ch. 18, Greenhouse Gas Emissions and Climate Change, 18-7 (2014).

²⁴⁷ NY Enviro. Conservation L. Art. 34

²⁴⁸ 6 NYCRR Part 505

revising the maps, and under the CRRA, will now be required to account for accelerated erosion due to sea level rise and coastal storms.

The CRRA also applies to New York's unique Local Waterfront Revitalization Planning process (LWRP), which is New York State's implementation of the Federal Coastal Zone Management Act of 1972.²⁴⁹ It authorizes local communities to prepare a comprehensive plan for waterfront issues and is administered by the NYS Department of State, Office of Communities and Waterfronts. Unlike many other plans, the LWRP is not just a set of recommendations. It is an enforceable set of policies implemented through municipal law. The Waterfront Consistency Review process, required under state law of any town with an adopted LWRP, reviews actions in the coastal area for consistency with the LWRP and coordinates review with the New York Department of State regarding federal and state actions. All projects must undergo Waterfront Consistency Review, except for specifically designated exempt actions. Project applicants must submit a Coastal Assessment Form similar to an Environmental Assessment form in Environmental Review under the federal National Environmental Policy Act or New York's similar State Environmental Quality Review Act. The town-designated agency (similar to the responsible agency under NEPA) makes the determination of consistency based on the submitted form and the LWRP coordinator's recommendation. If

²⁴⁹ Waterfront Revitalization of Coastal Areas and Inland Waterways Act (Art. 42 Executive Law).

the action is inconsistent, the applicant may need to modify their project or the project might be denied entirely. New York City's most recent LWRP mandates that climate change be considered in any project on its waterfront, and hence this requirement is mandatory for federal and state projects as well.²⁵⁰

3.6.7. New Jersey

While New Jersey does not have a statute specifically addressing sea level rise, the state has a history of passing some of the most extensive and complex regulatory schemes in the land use and environmental protection arena, and it has one of the most extensive coastal management programs as well. This complex system of regulation both constrains and empowers municipalities. State law, particularly the Coastal Area Facilities Review Act (CAFRA) requires extensive coordination with state agencies, since state oversight is strict.²⁵¹ But New Jersey is also a fiercely home rule state, and many state laws also empowers them to adopt innovative programs to protect their communities.

Although New Jersey must live with the historic legacy of intensive development up and down the Shore, many of the destructive trends of the past have slowed or stopped. As David N. Kinsey, former Coastal Management

²⁵⁰ City of New York, Department of City Planning, "Vision 2020: New York City Comprehensive Waterfront Plan," 2011, 112, accessed March 30, 2016, <u>http://www1.nyc.gov/assets/planning/download/pdf/plans-studies/vision-2020cwp/vision2020_nyc_cwp.pdf</u>.

²⁵¹ N.J. STAT. ANN. § 13:19-1 et seq.

Program Director with the New Jersey Department of Environmental Protection (DEP) wrote:

New Jersey's coastal management efforts have reversed several destructive trends. Filling of wetlands have virtually stopped...[n]ew highrises no longer mar scenic vistas...physical and visual access to beaches and waterfronts has increased for walking, fishing, swimming and enjoying the coast, through required public access paths, special beach shuttles to barrier islands, and local waterfront park development...critical natural habitats have been protected...²⁵²

All of this achievement has certainly had a cost, but Kinsey also believes predictability in public decision making has improved, and that development, while it may have slowed, has been instead directed to appropriate locations. High rises have only been built in areas where they previously existed and he even believes that "more than \$1 billion in casino-inspired boomtown development has taken place in the Atlantic City region, but not at the expense of the coastal environment."²⁵³

New Jersey witnessed an enormous surge in coastal construction particularly in the Post-World-War II years. In the 1960's over 1,500 acres of coastal wetlands were filled for coastal homes or industrial development. The New Jersey Wetlands Act²⁵⁴ successfully arrested the destruction of wetlands and the annual rate of wetlands filling fell to less than one acre by the end of the

²⁵² David N. Kinsey, "Lessons from the New Jersey coastal management program," *Journal* of the American Planning Association 51, no. 3 (1985), 330.

²⁵³ Ibid.

²⁵⁴ N.J.S.A. 13:9A-1 (1970)

1970s. However, it presented significant challenges, especially with enforcement, and this spurred the legislature to pass the New Jersey Coastal Facilities Review Act (CAFRA), which functions as the legal foundation for implementation of the state's Coastal Zone Management Program.²⁵⁵

The law places prohibitions on development in erosion hazard areas, contains setback provisions and provides definition of conditions under which ocean front shore protection structures are allowed, and requires the issuance of a permit for certain types of construction within the zone. The zone is set as by the ten foot contour interval as the inland coastal boundary. It is not pegged in any way to climate change, but the zone effectively covers an area much larger than the current flood zones. In total, 20% of New Jersey's land area, or 1,376 square miles, is covered under CAFRA, covering the ocean shore, industrial tidal riverfront, and bayshores.²⁵⁶

CAFRA requires an Environmental Impact Statement (EIS) be drafted as a component of a development application in the applicable zone, but unlike the California and North Carolina coastal acts as well as N.J.'s Pinelands, Highlands and Meadowlands special areas, CAFRA does not supersede local zoning authority and permits are not integrated with local processes.²⁵⁷

²⁵⁵ N.J.S.A. 12:5-3 (1973)

²⁵⁶ Kinsey, 331.

²⁵⁷ Ibid.

However, integration with local planning was significantly advanced when the 1993 amendments to CAFRA required integration with the N.J. State Plan. The State Plan is a unique process that attempts to preserve natural resources, coordinate planning activities, and establish statewide objectives for development, historic preservation, recreation and housing.

Municipalities are not officially required to participate in the process, although there are significant incentives to do so including higher priority for state funding, streamlined permit reviews and coordinated state agency service. The most significant, however, is that the law requires municipalities to participate in order to approve "centers," or state planning designations in the coastal region. Under state rules, the amount of impervious coverage permitted in the CAFRA zone is limited based on a parcel's location in a CAFRA zone - a center, core, node, Coastal Planning Area, or Coastal Center. The highest densities and coverages are allowed in the coastal or CAFRA Centers. If a town wants to permit development, it often had to have its impervious coverage limits increased by applying the state to change the designated CAFRA zone, which thus required that the town complete the process of plan endorsement. This allowed for greater control and coordination of planning at the state and local levels.

3.6.8. Delaware

The State of Delaware released a report on its vulnerability to sea level rise in July 2012. More recently, in 2013, the Governor issued Executive Order 41, "Preparing Delaware for Emerging Climate Impacts and Seizing Economic Opportunities from Reducing Emissions," which created a cabinet level committee to manage its climate adaptation and mitigation process.²⁵⁸ In March 2015, Governor Markell released "The Climate Framework for Delaware," which addresses recommendations from three subgroups: climate change mitigation, adaptation, and flood avoidance.²⁵⁹ It describes actions taken so far and makes recommendations for the future. The report lists 150 recommendations for actions that state can take to address climate change adaptation, and describes flood avoidance design guidance which requires consideration of sea level rise in state funded projects.²⁶⁰

The EO requires all state agencies to "incorporate measures for adapting to increased flood heights and sea level rise in the siting and design of projects..."²⁶¹ It further requires projects to "incorporate measures to improve resiliency to flood heights, erosion, and sea level rise using natural systems or

²⁵⁸ Del. Exec. Order No 41 (Sep. 12, 2013).

²⁵⁹ State of Delaware, Division of Energy and Climate, "The Climate Framework for Delaware," December 31, 2014, accessed March 30, 2016, <u>http://www.dnrec.delaware.gov/energy/Pages/Climate-Framework.aspx</u>.

nttp://www.anrec.delaware.gov/energy/Pages/Climate-Framework.aspx. ²⁶⁰ Ibid. ²⁶¹ Del Erree, Order No. 41 (Con. 12, 2012)

²⁶¹ Del. Exec. Order No 41 (Sep. 12, 2013)

green infrastructure whenever practical and effective."²⁶² If a project cannot avoid and must be constructed within the FEMA-designated Special Flood Hazard Area, the EO requires the structure to be elevated at least 18 inches above base flood elevation.²⁶³ Furthermore, if the area is mapped by DNREC as vulnerable to sea level rise inundation, the project be designed to anticipate sea level rise changes during the lifespan of the project on top of the FEMA flood levels. ²⁶⁴ It further requires all state agencies to "consider and incorporate the sea level rise scenarios set forth by the DNREC Sea Level Rise Technical Committee into appropriate long-range plans for infrastructure, facilities, land management, land-use, and capital spending."²⁶⁵

The executive order, while significant, contains the caveat that "no provision of this order shall create any individual right or cause of action that does not currently exist under state or federal law."²⁶⁶ While the executive order is an important step, this provision makes the order impossible to enforce by private action. In addition, the substantial research, report-drafting and executive action has not resulted in any statutes requiring action on sea level rise of other governments or citizens.

- ²⁶² Ibid.
- ²⁶³ Ibid.
- ²⁶⁴ Ibid.
- ²⁶⁵ Ibid.
- ²⁶⁶ Ibid.

Delaware's Coastal Zone Act focuses on strictly regulating new industrial development in the floodplain.²⁶⁷ Regulations passed in 1999 formalized implementation of the act. The regulations prohibit new heavy industry, expansion of any non-conforming uses, offshore gas, liquid, or solid bulk product transfer facilities, conversion of an existing unregulated, exempted, or permitted facility to a heavy industry use, bulk product transfer facilities and pipelines; construction, establishment, or operation of offshore gas, liquid, or solid bulk product transfer facilities; and new tank farms larger than 5 acres not associated with a manufacturing use.²⁶⁸

As described by Kenneth Kristl:

...driven by concern over the looming industrialization of its coast, the State of Delaware chose coastal resource preservation over unbridled industrialization when it enacted the Delaware Coastal Zone Act over significant opposition from business and various political interests.²⁶⁹

Kristl called the Delaware act and its absolute prohibitions "radical" and "unprecedented."²⁷⁰ He says the act has largely achieved what it intended, and that it should provide a model for other coastal states that want to protect their environment from industrial threats.²⁷¹ Even though the coastal zone act does not directly address climate change, the approach in Delaware sets a strong

²⁶⁷ Del. Code Ann. Tit. 7, § § 7001 (2007).

 $^{^{\}rm 268}$ Del. Code Regs. 7-100-101 .

²⁶⁹ Kenneth T. Kristl, "Keeping the Coast Clear: Lessons about Protecting the Natural Environment by Controlling Industrial Development under Delaware's Coastal Zone Act," *Pace Envtl. L. Rev.* 25, No. 37 (2008), 38.

²⁷⁰ Ibid., 42.

²⁷¹ Ibid., 103.

precedent for protecting the coastal environment especially now that the risks of climate change and sea level rise are acknowledged.

3.6.9. Maryland

Maryland's Governor O'Malley took action in 2007 when he issued an executive order to establish a Climate Change Commission that was to be divided into three working groups, one of which was an Adaptation and Response Working Group (ARWP).²⁷² The commission released a report in 2008, "Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change," which detailed its adaptation strategy and policy recommendations for sea level rise, coastal storms, erosion and coastal flooding. The report recommended that the state integrate erosion, storm and sea level rise adaptation strategies into existing state policies and programs, develop and implement state and local adaptation policies for public and private infrastructure, strengthen building codes, and promote shoreline and buffer area management practices, amongst other measures.²⁷³

Maryland recently passed a law tasking the University of Maryland Center for Environmental Science with establishing science-based sea level rise projections and update them every five years and providing its projections

²⁷² Md. Exec. Order 01.01.2007.07

²⁷³ State of Maryland, Commission on Climate Change Adaptation and Response Working Group. "Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change." (2008). http://www.mde.state.md.us/assets/document/Air/ClimateChange/Chapter5.pdf

publicly on the internet.²⁷⁴ Maryland law also requires the Department of the Environment to consider sea level rise as well as danger from hurricanes and floods, when evaluating a tidal wetlands license or permit application.²⁷⁵

Maryland also passed a law to address sea level rise and coastal flooding impacts on capital projects planned and built or funded by the state.²⁷⁶ It requires the Coast Smart Council establish siting and design criteria to address sea level rise and coastal flooding impacts, and directs the council to include a requirement that "the lowest floor elevation of each structure located within a special flood hazard area is built at an elevation of at least 2 feet above the base flood elevation."²⁷⁷

3.6.10. Virginia

Governor Timothy M. Kaine established the Governor's Commission on Climate Change in December 2007 and the commission issued a report in December 2008. In 2014, Governor McAuliffe signed an executive order convening the Climate Change and Resiliency Update Commission.²⁷⁸

²⁷⁴ Md. Code, Environment, § 2-1306

 $^{^{275}}$ Md. Code § 26.24.02.03

^{276 § 3-602.3 (}b)(1)

^{277 § 3-602.3 (}c)(2) iii.

²⁷⁸ Governor of Virginia, Press Release, "Governor McAuliffe Signs ExecutiveExexcutive Order Convening Climate Change and Resiliency Update Commission," accessed March 30, 2016, <u>https://governor.virginia.gov/newsroom/newsarticle?articleId=5342.</u>

The plan suggests sea level rise will be a major issue for the state of Virginia and particularly the Hampton Roads metropolitan area.²⁷⁹ The plan cites the Chesapeake Bay Program Scientific and Technical Advisory Committee which projects sea levels to rise in the Chesapeake Bay by 0.7-1.6 meters by 2100.²⁸⁰

The plan also recommends that local governments include climate change in local planning efforts. It states:

Local governments in the coastal area of Virginia should include projected climate change impacts, especially sea level rise and storm surge, in all planning efforts, including local government comprehensive plans and land use plans. Local governments should revise zoning and permitting ordinances to require projected climate change impacts be addressed in order to minimize threats to life, property, and public infrastructure and to ensure consistency with state and local climate change adaptation plans.²⁸¹

The plan is only advisory, but Virginia recently enacted a statute that mandates municipalities in the Hampton Roads Planning District Commission incorporate strategies to combat projected relative sea level rise and recurrent flooding in their comprehensive plans.²⁸² The reviews must be also be coordinated with other localities in the Hampton Roads region.²⁸³ The statute also directs the Virginia Department of Conservation and Recreation, the Department of Emergency Management, the Marine Resources Commission,

²⁷⁹ Va. Governor's Commission on Climate Change, Report, Section III.A.

²⁸⁰ Ibid.

²⁸¹ Governor's Commission on Climate Change, Report, Section 14.C.

 $^{^{282}}$ VA Code Ann. § 15.2-2223.3

²⁸³ Ibid.

Old Dominion University, and the Virginia Institute of Marine Science to provide technical assistance to any municipality upon request. ²⁸⁴ Furthermore, the statute specifies that if a local hazard mitigation plan is prepared, it may be incorporated into the comprehensive plan.²⁸⁵

C HAPTER 4 - METHODS

4.1. RESEARCH DESIGN

This study used a mixed methods approach consisting of three different parts to inventory and measure the benefits of climate change adaptive practices in 34 coastal communities in the ten states in the North Atlantic region, consisting of Maine to Virginia. Part I comprises an inventory and assessment of the adaptive practices found through semi-structured interviews, expert review and archival analysis, which was the scope of a study funded by the National Oceanic and Atmospheric Administration (NOAA)/Sea Grant, entitled *Cost-Efficient Climate Change Adaptation in the North Atlantic*. Part II consists of the results of an on-line survey, administered to municipal planners and staff, to gather more information about the cost, effectiveness, and transferability of specific adaptation actions inventoried in Part I. Part III assesses the legal feasibility of expanding the use of highly promising adaptive strategies found in the region utilizing legal and archival methods.

4.2. DEFINING THE SCOPE OF THE STUDY

4.2.1. Goals of Study

The scope of this study was originally guided by a NOAA funded fellowship project, and expanded upon for the purposes of this doctoral thesis project. The original purpose of the NOAA study was to enable the transfer of locally-driven climate change adaptation best practices in coastal communities. The need for the study commissioned by NOAA was documented by a needs analysis. NOAA, which is primarily responsible for predicting weather and climate in the United States, found that models and predictions were not being transferred to action in the planning and policy arena. When polled about the challenges to implementing action, municipal leaders indicated that the lack of available examples and models was an impediment. Consistent with that charge, two main outreach information products were produced: a database of best practices and case studies.

Database of local climate change and related coastal hazard management best practices. All potential best practices found during the research were included in a table with basic descriptive information.

Case studies. In-depth analysis and description of communities and their adaptation activities was provided in a municipality-by-municipality format to report adaptation.

Two individuals were selected as fellows carried out the research beginning in January 2012 and ending October 2012, coincidentally just before Superstorm Sandy struck the North Atlantic coastline. The fellows chosen were Judd Schechtman, author of this thesis, and Michael Brady, Ph.D. student at Rutgers University Department of Geography. NOAA established a Steering Committee (SC) consisting of 15 recognized experts including advisors Clinton Andrews, Ph.D. of Rutgers Bloustein School and William D. Solecki, Ph.D. of Hunter College, as well as from organizations such as NOAA's New England Coastal Services Center, NOAA's National Climactic Data Center, Sea Grant offices in New York, Massachusetts, Delaware, and Connecticut, state offices such as Massachusetts' Coastal Zone Management division, and the Narragansett Bay National Estuarine Research Reserve. The SC held monthly teleconferences to help guide the project.

As an expert panel, the SC helped to set the criteria for the methods and the geographic and content scope of the research. NOAA published the final report, *Cost-Efficient Climate Change Adaptation in the North Atlantic* on-line and in print. Parts II and III of this report consist of a follow-up on-line survey and a legal/archival analysis, and were completed exclusively for this doctoral dissertation.

Member	Affiliation
Clinton Andrews, PhD	Rutgers University, Bloustein School
Nicole Bartlett	NOAA North Atlantic Regional Team
Gregory Berman	Woods Hole Oceanographic Institute Sea Grant
Wendy Carey	Delaware Sea Grant
Nordica Holochuck	New York Sea Grant - Hudson River Valley
Sylvain DeGuise	Connecticut Sea Grant
Adrianne Harrison	NOAA Coastal Services Center, New England
Darlene Finch	NOAA Coastal Services Center, Mid-Atlantic
Julia Knisel	Massachusetts Coastal Zone Management
Ellen Mecray	NOAA National Climatic Data Center
Jennifer Pagach	Connecticut Dept. of Energy & Environmental Protection
William D. Solecki, PhD	Hunter College, Dept. of Geography
Jay Tanski	New York Sea Grant – Long Island
Esperanza Stancioff	Maine Sea Grant
Jennifer West	Narragansett Bay National Estuarine Research Reserve

The members of the steering committee were as follows:
4.2.2. Unit of Analysis

As per the scope of the NOAA study, we focused on municipal-scale management activities to document projects and enable sharing of climate change adaptations in the North Atlantic region. The geographic scope of the project was defined as the North Atlantic, including the New England states of Maine, New Hampshire, Massachusetts, Rhode Island and Connecticut, and



Figure 5: Municipalities comprising the sample for the study

State/Municipality	Number of Adaptation Actions	State/Municipalit	
Connecticut	12	New Hampshire	
Greenwich CI	6	Hampton NH	
Groton CT	2	Portsmouth NH	
Guilford CT	1		
Delaware	14	Greenwich, NJ	
Bowers, DE	4	Little Silver, NJ	
Lewes, DE	4	Oceanport, NJ	
New Castle County, DE	4	Sea Isle City, NJ	
New Castle, DE	2	New York	
Maine	15	East Hampton, NY	
Ogunquit, ME	3	New York, NY	
Saco, ME	3	Southampton, NY	
Scarborough, ME	5	Southold, NY	
York, ME	4	Rhode Island	
Maryland	12	North Kingstown, RI	
Crisfield, MD	3	Virginia	
Ocean City, MD	3	Hampton, VA	
Somerset County, MD	1	Norfolk City, VA	
Worcester County, MD	5	Poquoson, VA	
Massachusetts	19	Portsmouth, VA	
Barnstable, MA	5		
Brewster, MA	4		
Hull, MA	7		
Marshfield, MA	3		

Table 2 - Sample States, Municipalities and Number of Adaptation Actions in Each

the Mid-Atlantic region, including the states of New York, New Jersey, Delaware, Maryland, and Virginia.

Within the geographic guideline, sample communities were chosen on the basis of: A) A fair distribution amongst the ten states in the North Atlantic region;B) Communities had to be known as taking a leadership role or otherwise advancing activity relating to climate change adaptation and coastal hazards; and C) Independent local governing bodies with an executive and legislature.

We had difficulty finding sufficient actions in municipalities in some states, such as Rhode Island and New Hampshire, likely due to their small size and short coastlines, and wound up with fewer towns and actions in these states. Communities were initially suggested by Steering Committee members, as well as independent literature and internet searches. Subsequently, additional communities were incorporated into the project based on a snowball technique, with sample communities recommending other communities engaging in innovative practices. We also strove to select communities with divergent geographic, governance and population characteristics, such as large cities (e.g. New York, New York) and small coastal towns (e.g. Barnstable, Massachusetts), working-class coastal resource dependent communities (e.g. Crisfield, Maryland), and resort destinations (e.g. Lewes, Delaware), highly urbanized shorelines (e.g. Ocean City, Maryland) and rural natural areas (e.g. Greenwich, New Jersey). Communities and adaptations were screened by the researchers for compliance with established inclusion criteria.

The final selection of communities for the study included 2 boroughs, 12 cities, 3 counties, 17 towns, and 1 township. The list of municipalities and states, as well as the number of adaptive actions found in each, is shown in Table 2.

4.2.3. Adaptation Activity Selection

To determine which actions were to include in the inventory, we defined what constituted a "climate change adaptation," as well as what constituted a "local activity." To define the scope of a climate change adaptation, we consulted the literature, including Adger et al., which suggests that individuals and communities are much more likely to respond to experiences of current climate variability, such as a recent flood or damage from a hurricane, than to expected or future climate change. ²⁸⁶ As such, harnessing benefits that both respond to current climate hazards and adapt the community to climate change are an essential component to achieve meaningful adaptation. In realization of this paradigm, we defined climate change adaptations as including both strategies that explicitly respond to future climate change or its impacts, and those that respond to current climatic conditions.

To meet the definition of a locally-driven activity, the action had to be duly adopted or engaged in by a local government. In addition, the practice had to either constitute an independent activity of the local government, be a voluntary local implementation of a state or federal program that supersedes

²⁸⁶ W. Neil Adger, Surraje Dessai, Marisa Goulden, Mike Hulme, Irene Lorenzoni, Donald R. Nelson, Lars Otto Naess, Johanna Wolf, Anita Wreford, "Are there social limits to adaptation to climate change?"?, "*Climactic Change* 93 (2009):335-354; *See also* Susanne C. Moser and Lisa Dilling, "Making Climate Hot. Communicating the Urgency and Challenge of Global Climate Change," *Environment* 46, no. 10 (December, 2004): 32-46.; and D. Paton, M. Millar, and D. Johnston, "Community resilience to volcanic hazard consequences," *Natural Hazards* 24, no. 2 (2001): 157-169.

minimum requirements, or be a voluntary partnership with higher levels of government or other partners.

4.3. DATA COLLECTION

Data was obtained through in-person interviews, internet-based surveys, through direct observation of coastal zones and adaptation projects, and analyses of local plans and laws. An Institutional Review Board (IRB) exempt review proposal was prepared on grounds that the subjects were government officials. However, it was later determined that IRB approval was not necessary for this project, because it is not considered "human subjects research" within the meaning of the Code of Federal Regulations,²⁸⁷ which is defined as "a living individual about whom an investigator conducting research obtains (1) data through intervention or interaction with the individual, or (2) identifiable private information." Because the information gathered was about the public activities and laws of the local government the interviewees and survey respondents were employed for, and not the subject him or herself, the project is not considered human subjects research. However, as part of the process, an informed consent form was drafted, and we choose to present the form to each of the subjects to read and sign before the interview, as an extra safety protocol. The consent form appears in the appendix.

²⁸⁷ 45 CFR 46.102(f)(1),(2)

4.3.1. In-Person Interviews

All communities were visited by the author, by co-fellow Michael Brady, or by both individuals for observation and to conduct in-person interviews and field observations between June 2012 and October 2012. Semi-structured in-person interviews focused on gathering information on each municipality's climate change adaptation actions were conducted with key informants, such as town planners, emergency managers, councilmembers, chief executives, and environmental commission members. Interviews were conducted in the offices of local governments, such as town halls, offices of planning and engineering departments, departments of public works, or departments of emergency management. One interview was conducted in each community, with the exception of Ocean City, Maryland, where a follow-up interview was conducted.

Interviewees were not compensated and participation was voluntary. The number of interviewees varied from one-on-one in private offices to up to 20 participants in town hall chambers. Most consisted of between two and four town staff. Interviews generally lasted about an hour. The interviews were electronically audio recorded via iPhone and were not transcribed. Any subsequent information or clarification needed was obtained by listening to the interview recordings. The interview protocol was drafted by the researchers and finalized with input from the expert SC panel.

Because the purpose of interviews was to gather general information about actions municipalities were taking to adapt to climate change, we used a semistructured format to allow for the interviewees to direct the conversation. Topics covered in the protocol included broad questions, such as whether climate change is seen as a relevant issue in the community and whether citizens are concerned about the impacts of climate change. Questions were also asked about specific actions, such as whether the town adopted regulations as a direct result of concern about climate change or sea level rise or had adopted regulations that had the effect of adapting to climate change or sea level rise. Specific questions were asked about whether the town had adopted a climate change, comprehensive, or hazard mitigation plan. We also asked if the town had adopted any regulations that were unique or superseded state or federal law, and asked questions about specific implementation strategies, such as coastal zone setbacks, wetland preservation, participation in the FEMA Community Rating System program and adopted floodplain regulations. A copy of the interview protocol is presented in the appendix.

4.3.2. Field Observation

Each community was visited to conduct an interview and for field observation. Field observation of adaptations were conducted after interviews pointed us to specific locations in the community where adaptive actions could be observed. In some cases, such as in Groton, Connecticut, the town staff led a guided tour of vulnerable areas and adaptive actions, in others, the researchers observed projects on their own. Photographs were taken of many observable adaptations for inclusion in the NOAA report, including coastal open spaces such as dunes and wetlands, infrastructure such as sea walls and bulkheads, and places where homes were being elevated. The field observations sometimes led to discovery of additional actions that were included in the data; and many times led to further questions for follow-up contact with interviewees for clarification.

4.3.3. Surveys

More specific information about communities' adaptations was obtained via a follow-up survey. The survey was designed primarily to address gaps in knowledge as well as to more precisely measure costs and effectiveness. The survey consisted of seven multiple choice and two open response repeated for each action. It was administered to a primary contact in all municipalities that participated in the initial interviews and plan reviews. After multiple contact attempts, 33 of 34 municipalities responded and completed the questionnaire. The questions were informed primarily by gaps in data collected during the interviews, expert guidance by the SC, and generally by the work of Adger et

al.²⁸⁸ The questions in the survey are presented in the following section along with the rationale of including each.

1. COSTS: Indicate the approximate cost to the town to participate in the program/project.

The first question addresses the need to obtain more specific cost information than we gathered during the interviews. Interviewees had a difficult time estimating cost and defining costs to whom, and discussions were not precise enough to obtain this information about each specific adaptation. To make this simpler and clearer to answer, we narrowed the issue to only focus on costs to the municipality and provided ranges of costs in a multiple choices format. Answers were provided in multiple choice format consisting of:

- A) None
- B) Very Low (<\$1,000)
- C) Low (<\$10,000)
- D) Medium (<\$100,000);
- E) High (<\$1,000,000)
- F) F. Very High (>\$1,000,001)
- G) N/A

2. MOTIVATIONS: What were the most important motivations behind participating in the project/program?

²⁸⁸ W. N. Adger, N.W. Arnell, and E.L. Tompkins, "Successful adaptation to climate change across scales," *Global Environmental Change* 15 (2005): 77-86.

We recognized that communities are more likely to respond to natural hazards of a more immediate concern than to future climate change. In addition, actions might have more than one source of motivation. Smith et al. suggests that many actions taken in response to climate change should be 'no regret' measures that also have ancillary benefits.²⁸⁹ Question two therefore was designed to gather information on the sources of motivation for each action. Answers were provided in multiple choice format consisting of options suggested by information gathered during the interviews, including:

- A) Funding was available
- B) To earn Community Rating System (CRS) credits
- C) Response to constituent concerns
- D) Elected officials advocated
- E) To protect the community
- F) For environmental or resource conservation
- G) To reduce development pressure
- H) Other

3. EFFECTIVENESS: Indicate how effective you believe participating in the project/plan is at reducing the community's vulnerability to climate change and sea level rise?

We asked question three based on the guidance of Adger et al. who suggest four criteria for measuring the success of climate change adaptations, including effectiveness, efficiency, equity, and legitimacy. They defined

²⁸⁹ J.B. Smith, S.E. Ragland, and G.J. Pitts, "A process for evaluating anticipatory adaptation measures for climate change," *Water, Air and Soil Pollution* 92 (1996): 229–238, doi:10.1007/BF00175568.

effectiveness as the capacity of an adaptation to achieve its expressed objectives. An explicit definition was not provided, as we preferred to leave it open to participants. Responses were scored on a Likert scale from one (not effective) to five (very effective).

4. IMPROVING EFFECTIVENESS: What would you say would make the project/program more effective?

We asked a multiple choice question about what might improve effectiveness, incorporating choices that appeared most probable, given information gathered during interviews and analysis of plans and laws.

Options for selection included:

- A) Education
- B) Funding
- C) State or Federal legal changes
- D) State or federal technical assistance
- E) Other

5. FUNDING SOURCES: If participation in the project/plan received external funding, please indicate the source of that funding:

Determining whether projects were externally funded, and if so, what the sources of funding were, was an important component of the original scope of the NOAA project. It was hypothesized that many of the actions taken by communities would be driven by self-interest, and that external motivation, such as mandates or funding, would be needed to invoke adaptation action. We asked question five to gather data on this issue, and provided multiple choice responses including:

- A) FEMA
- B) Army Corps
- C) NOAA
- D) State
- E) Non-profit or foundation grant
- F) Project did not receive external funding

6. REPLICABILITY: Would you say the project/program could be easily replicated in other communities?

Adger et al. suggest a criteria called "legitimacy," which is defined as "the extent to which decisions are acceptable to participants and non-participants that are affected by those decisions."²⁹⁰ We measured the related construct of replicability, a specifically referenced need in the NOAA project, which is a measure of the extent to which the project is acceptable to those in the community and perceived acceptability in other communities. Responses were in the form of a Likert scale from one (not effective) to five (very effective).

7. CHECK FOR CRITERIA: Was the project/program:

This question validated that the specific adaptation action asked about met criteria for inclusion. Options included:

- A) Entirely locally driven and executed
- B) Meeting a state or federal requirement

²⁹⁰ W. N. Adger, N.W. Arnell, and E.L. Tompkins, "Successful adaptation to climate change across scales," *Global Environmental Change* 15 (2005): 77-86, 83.

C) Meeting a state or federal requirement, but going beyond state or federal minimums in its execution

D) A partnership with multiple levels of government involved

E) Other

8. CHECK FOR INCLUSIVENESS: Please list any other climate change, sea level rise or coastal resilience adaptations that are stricter than state or federal law that we missed.

This question validated that we did not miss any actions. An open response box was provided.

9. BENEFITS IN RECENT STORMS: In what way did these or other adaptations specifically protect the community in Hurricane Sandy?

Because the data was originally collected before Hurricane Sandy struck, we decided to ask an open-ended, narrative response question that could provide additional information on benefits.

4.3.4. Analysis of Plans and Local Laws

Once interviews and field observations were completed, information gathered was supplemented with further research by analysis of municipal plans and local laws, as well as other documents shared by the SC and interviewees, to further understand the historical and policy context and details of the actions. Summaries of the text of local laws and details of actions, such as specific sections of a zoning code describing wetland and dune line setbacks, or sections of comprehensive or other local plans, were consulted and incorporated into the NOAA report and presented as cases here. Textual analysis of plans allowed us to measure additional variables not obtained by survey or interviews. Specifically, we assessed whether each adaptation explicitly incorporated climate change. Some adaptations were directly responsive to or incorporated future projections of climate change, while others were simply responding to coastal hazards in the current climate. In the results table this is represented as a binary variable – zero if the adaptation did not incorporate climate change and one if it did.

4.4. DATA VALIDATION

In addition to inclusion criteria and inclusiveness checks as outlined above, data validation of reported detail of adaptations during interviews was conducted by reviewing documents such as plans and town codes. Member checks were also conducted by sending adaptation summaries to town officials and staff for reviews and correction. Email and telephone calls to the interviewees supplemented this information and provided further clarification on any points of uncertainty. A report was drafted consisting of summaries about each municipality and its climate adaptation actions. Each municipality's summary was circulated back to staff to municipal staff to validate this information. The summaries became part of the NOAA report and informed the analysis and results.

4.5. INDIVIDUAL MEASURES AND CONSTRUCTION OF AN ADAPTATION QUALITY INDEX

An adaptation quality index was constructed, but then later dispensed with. The initial purpose was to gather an overall measure of the usefulness of the adaptations. The index was calculated by adding the values of the measures gathered in the survey – including effectiveness, replicability, the inverse of the cost rank, plus a binary score (of zero or one) for incorporation of climate change.

Quality Index = (Inverse of Costs Rank) + (Effectiveness) + (Replicability) + (Incorporation of Climate Change)

Inverse Costs Rank represents a number from one to five corresponding to the answer supplied by the survey respondents on the question indicating the total cost of the adaptation program to the municipality as follows:

5 = \$0 to \$1000 4 = \$1001 to \$10,000 3 = \$10,001 to \$100,000 2 = \$100,001 to \$1,000,000 1 = Over \$1,000,001

Effectiveness represents a number on a Likert scale from one to five as replied by survey respondents, with five being most effective and one being least. Replicability represents a number on a Likert scale from one to five, with five being most replicable and one being least. Incorporation of Climate Change represents a binary response – either zero or one – zero if the adaptation did not incorporate climate change and one if it did. Rankings were averaged across different categories of adaptations, and average index rankings were plotted for practice type. T-tests of independence were conducted to determine if the quality of the adaptations (as measured by averaging the adaptation quality index scores by category) is related to the frequency of the adoption of the adaptations (by practice type and by adaptation strategy). Cronbach's Alpha was also calculated, which provide a measure of reliability between the measures of the index by determining the average correlation of the various index values.

4.6. COMMUNITY TYPOLOGIES

Predominant coastal geography of each community was identified and characterized. A community could be defined as Oceanfront, Bayfront, Soundfront, Harborfront, or both Bay and Oceanfront. Oceanfront is defined as a community has an open ocean shoreline. Communities fronting an open coastal bay, such as the Saco Bay in Maine, were characterized as oceanfront. Communities on barrier islands are both ocean and bayfront. Bayfront is defined as communities with coastal frontages only on sheltered bays, such as Delaware Bay and Chesapeake Bay. Soundfront is a community located on a sound, which is defined as a long passage of water separating a mainland and an island. The only soundfront communities in our study fronted the Long Island Sound either in New York or Connecticut. Harborfront is defined as a community fronting on a sheltered body of water. Portsmouth, New Hampshire is our only harborfront town, in this case, with an outlet to the Atlantic Ocean just a few miles downriver.

Communities were also defined by their level of urbanization, which could be either Seasonal, Suburban, Urban, or Rural. Seasonal communities were defined as having more than 20% of their housing reported as seasonal, based Suburban communities were on census data. those metropolitan municipalities not the center of their urbanized area. Urban is defined as metropolitan communities that have a primary downtown or commercial district in their urban areas. Rural is defined as low-density, primarily agricultural or resource-based communities. Communities that had two distinct shores could be considered both, but towns entirely on barrier islands were classified separately as such. Only one community, Portsmouth, New Hampshire was classified as harborfront since the largest body of water it fronts is otherwise a river.

4.7. DATA CATEGORIZATION

Categories were subsequently created to classify and analyze adaptations on a number of different dimensions subsequently used for analysis, including: IPCC Strategy, Practice Type, Practice Subtype, Incorporation of Climate Change, Enforcement Strength and Independence of Action.

CHAPTER 5-FINDINGS AND DISCUSSION

5.1. OVERALL FINDINGS

The findings revealed that coastal communities are using a wide range of tools with unique local solutions to adapt to worsening coastal hazards, sea level rise and climate change. Results indicate that systematic incorporation of climate change concerns into formal community planning, management, and infrastructure design is in a nascent stage. Yet, we found innovative climate change and flood management practices in every state in the region, and in diverse municipalities with varying demographic and geographic characteristics.

Actions communities took ranged from climate change studies, to laws and policies, to outreach tools and infrastructure investments. Many were completely unique, ground-up initiatives. Some others included collaborations across NGOs, neighborhood associations, and academic institutions. Others were implementations of state law, or responded to incentives from the federal or state government, but many communities demonstrated willingness to go beyond mere requirements and pass laws with stricter enforcement standards.

5.2. DATA CATEGORIES

Categories were created to classify adaptations on a number of different dimensions, including: IPCC+2 strategy, Practice Type, Practice Subtype, Incorporation of Climate Change, Enforcement Strength and Independence of Action. They are illustrated in the able below, and each is described in the sections that follow.

IPCC Strategy	Practice Type	Subtype	Incorporation of Climate Change	Enforcement Strength	Independence of Action
Accommodation	Administrative	N/A	No.	Advisory	Above Required
Prevention	Capital Investment		Yes	Implemented	Unique
Procedural		Gray Infrastructure		Incentive	
Protection	1	Green Infrastructure		Mandatory	1
Retreat	Education/Outreach	N/A		Permissive	1
	Law]	Proposed]
		Building Code			×.
		Law - Land Use			
		Law - Fiscal			
	Plan				
		Plan - Comprehensive			
		Plan - HMP			
		Plan - Other			
	Policy	N/A			
	Study/Pilot Project	N/A			

Table 3 – Adaptation data categories



Figure 7 - Distribution of projects by IPCC strategy



Figure 6 - Average effectiveness, replicability ratings, and costs of adaptations by IPCC strategy

5.3. IPCC STRATEGY

In 1990, the Intergovernmental Panel on Climate Change (IPCC) identified of three types of strategies to adapt to sea level rise: accommodation, protection, and retreat.²⁹¹ Accommodation actions involve strengthening resilience but do

²⁹¹ Intergovernmental Panel on Climate Change (1990).

not attempt to halt floodwaters, such as relocating utilities or elevating structures. Protection actions involve infrastructure to keep the sea at bay, such as building seawalls or dunes. Retreat is defined as actions that allow existing ecosystems to shift landward – and often explicitly involve relocating communities. They include buyouts of repetitive loss properties and Transfer of Development Rights (TDR) programs that move development back from the immediate shoreline. Many adaptations were identified as falling within these categories. Many adaptations, in fact, the most common type of adaptations found, do not fit within these three, and hence we propose two new types be added to the scheme: prevention and procedural. Prevention is defined as activities that preemptively thwart development from taking place. The IPCC classification included these actions, such as land conservation or the purchase of conservation easements under retreat, but they are fundamentally different. They should be distinguished from retreat, which is often associated with politically treacherous actions that imply community displacement.

Procedural adaptations are defined as projects that generate information, such as studies, mapping exercises, administrative or educational programs, or projects that incorporate that information into plans or other administrative or legal processes. These types of activities are essential to adaptation over the long term, although they may not have immediate results visible in the built environment and thus were not contemplated by the IPCC classification system. The distribution of adaptation strategies is depicted in Figure 6. Procedural adaptations were the most common, representing 52%. Accommodation actions were second most common, with 21% of adaptations falling into this category. 19% of actions were classified as prevention and protection strategies represented 6%. The least-utilized type of strategy was retreat, representing just 3% of actions. The chart in Figure 7 depicts average effectiveness and replicability ratings by IPCC strategy. The following section details examples of each type of strategy.

5.3.1. Accommodation

Accommodation actions are defined as those that strengthen resilience but do not attempt to stop inundation. The second largest number of strategies (21%) were of this type. Examples include requiring elevation of structures, requiring



Figure 8 - This home being elevated in Poquoson, VA is a good example of accommodation

the installation of breakaway flood walls and flood venting, requiring or allowing utilities to be moved to the roof, or allowing height limit waivers.

Freeboard is the most common type of adaptive building code requirement identified. Freeboard is defined as a requirement for elevating the lowest floor of a structure, including the basement, above the FEMA designated base flood elevation (BFE), otherwise known as the expected level of the 1% (100-year) flood. Twelve municipalities required freeboard above FEMA or state minimums. Ocean City, Maryland requires the greatest freeboard in our sample - its most stringent zone requires up to 5.5 feet above BFE.²⁹² Most other structures in the flood hazard zones are required to be elevated two or three feet above the BFE.²⁹³ In the V-zone, Ocean City, Maryland prohibits wood pilings above grade, and buildings are required to be supported by reinforced concrete piers or concrete foundations that are constructed to 8.5 feet below sea level. The code also prohibits manufactured buildings in the V zone.²⁹⁴ Saco, Maine requires three feet of freeboard in some of its flood zones; Worcester County, Maryland, Oceanport, New Jersey, and Crisfield, Maryland require two feet above BFE, and Greenwich, Connecticut, New Castle County,

²⁹² Ocean City, Md., Town Code, § 38-71 (a)(1) requires a minimum elevation of 16.5 feet above mean sea level in the V zone. Mean Sea Level is 17 NGVD 1929, the datum used on current flood maps for Ocean City, and most of the area within V zone has a BFE of 11 ft. NGVD.

²⁹³ Ibid. § 38-71 (a)(2)-(4)

²⁹⁴ Ibid. § 38-75 (a), §10-228

Delaware, Norfolk, Virginia, Poquoson, Virginia, and Portsmouth, Virginia require one foot.

Most accommodation actions do not specifically reference climate change or sea level rise, but rather explicitly regulate some aspect of private property rights - such as elevation of buildings. Barnstable, Massachusetts is an exception, as they have explicitly referenced sea level rise in an ordinance. The town of Barnstable recognized that a historic beach community, known as the Craigville Beach area and the Centerville Village Center, are at particular risk to coastal flooding. The town enacted a special zoning ordinance as part of the designation of the Craigville Beach area as a District of Critical Planning Concern. Districts of critical planning concern are permitted under the Cape Cod Commission legislation, and they allow towns to supersede state law with respect to certain regulations, including requiring freeboard of structures above the state standards.

The purpose and intent section of the town code states: "As the entire complex of coastal wetland resources moves landward due to relative sea level rise, the Craigville Beach area's coastal floodplains immediately landward of salt marshes, coastal beaches, barrier beaches, coastal dunes, and coastal banks require special protection."²⁹⁵ The law requires structures in the V zone and

²⁹⁵ Town of Barnstable, Town Code §240-131.1

the A zone to be elevated to two feet and one foot above base flood elevation respectively. ²⁹⁶ The special district, which was also concerned with preservation of views and community character, specifically allows for waiver of height limits up to 2 feet above BFE when necessary to elevate a structure.²⁹⁷

5.3.2. Prevention

Prevention is defined as anticipatory actions taken to protect or preserve land in its natural state that prevents exacerbation of coastal hazards. 16% of projects were classified as prevention. Examples of prevention projects include restricting floodplain development through a number of regulatory measures, including setting minimum lot sizes and setbacks, as well as restricting shoreline structures, vegetation preservation, cluster zoning and transfer of development rights, as well as taxation schemes designed to preserve land.

The Coastal Overlay District ordinance in East Hampton, New York is an example of an innovative prevention project that prevents degradation of the

 $^{^{296}}$ Town of Barnstable, Town Code $\$240\mathchar`-131.7$

 $^{^{297}}$ Town of Barnstable, Town Code $240\text{-}131.5\ (\mathrm{C})$



Figure 9 - East Hampton, N.Y.'s coastal overlay district and strict bluffline setbacks prevent degredation of these natural dunes and native vegetation.

natural defenses present along the town's coastline.²⁹⁸ The law regulates and limits the placement of shoreline hardening structures such as groins and seawalls. The Coastal Overlay District establishes four zones adopted from the town's use district map and incorporated into its zoning code.²⁹⁹ Construction of erosion control structures is banned in three of the four zones and severely restricted in the fourth. Erosion control structures are prohibited along the entirety of the ocean shoreline and most of the inner harbors. However, as with all zoning regulations, landowners may bring a variance case to the board of standards and appeals, and many such exemptions are issued. The boundary of the town's coastal erosion overlay district includes all areas located up to 200 feet landward from the mean high water line and 1,000 feet seaward from

 ²⁹⁸ Town of East Hampton, N.Y., Town Code § 255-3-80
²⁹⁹ Ibid.

the mean low water line.³⁰⁰ The erosion zones are a component of the town's zoning code and designated as specific use districts. Zone 1 is the ocean coastal zone, which is has few erosion control structures. Zone 2 is the bay coastal zone and also has few erosion control structures. Zone 3 is the bay zone, which contains erosion control structures that are isolated and discontinuous. Zone 4 is the bay coastal zone, with many erosion control structures and seriously compromised natural defenses. In this latter zone, new erosion control structures may be permitted by special permit.³⁰¹ The loss of "...features such as bluffs, dunes, and beaches means that in many cases erosion control structures provide the only remaining protection against flooding and erosion." 302 The code contains a number of especially notable features. Furthering the protective value of the code, the lot area definition excludes areas seaward of the dune line or bluff crest as well as tidal and freshwater wetlands. The town also does its own surveying for the wetlands and bluff lines to ensure compliance.

The code also contains a number of other exemplary prevention regulations. It prohibits "grading, dredging or building within 100 feet of the inland boundary of any beach" ³⁰³ and "within 150 feet of the bluff line along the Atlantic

³⁰⁰ Ibid.

³⁰¹ Ibid.

³⁰² Ibid. § 255-3-80

³⁰³ Ibid. § 255-4-20 (B)

Ocean."³⁰⁴ In addition, "within 200 feet of the inland boundary of any beach, constructing a cesspool or septic tank or any tank for fuel" is prohibited.³⁰⁵ The town's vegetation preservation ordinance also limits clearing of native vegetation to specific percentages of the parcel based on its size. The removal of any vegetation other than listed non-native species and dangerous deadwood is considered to be a clearing. The code also prohibits the "clearing, removing, uprooting, burying or otherwise damaging any beach vegetation, or replacing the same with lawn, sod, or turf" in the VE flood hazard zones within the Flood Hazard Overlay District.³⁰⁶

Perhaps one of the best examples of prevention actions is the Peconic Bay Region Community Preservation Act, which authorized a real estate transfer tax program that generates funding for land preservation in the five towns on eastern Long Island, including in East Hampton.³⁰⁷ A plan in each town sets the list of eligible priorities, describes mechanisms for protection, and determines which properties should be given highest priority. Different tools are available to the town given unique circumstances with each property. Conservation easements and purchase of development rights are commonly used, as well as bargain sales, charitable reminder trusts, and land donation.

³⁰⁴ Ibid. § 255-4-20 (C)

³⁰⁵ Ibid. § 255-4-20 (B)(2)

³⁰⁶ Ibid. § 255-4-20

³⁰⁷ Ibid. § 64-e

In East Hampton, the cumulative total revenue since 2001 from transfer tax receipts, interest, co-op sales, donations and rental agreements amounts to \$205,295,221.³⁰⁸ As of the report date, the town had acquired interests or rights in 205 parcels totaling 1,658 acres.³⁰⁹ In Southampton the program has generated over \$384 million and has protected over 3,000 acres of land.³¹⁰

However, not all of the land acquisitions under the plan are actually climate adaptive. Southold has six categories of acquisition including Parks and Recreation, Wetlands, and Beaches and Shoreline amongst others such as farmland and historic sites. The Beaches and Shoreline category include dune lands, bluffs, bayfront, oceanfront, and lakefront property. 345 acres in this category were identified in the plan as eligible for acquisition, including a 122 acre beachfront parcel acquired with the county, state and a federal grant, another 150 acres jointly acquired with the state and county as well as smaller parcels by the town alone.³¹¹

In Southampton, the second project update consisted of eight target areas for acquisition.³¹² The Pine Barrens represent the largest acreage targeted for acquisition, as well as agricultural land and land for aquifer recharge. Coastal

³⁰⁸ Town of East Hampton (2012). Community Preservation Fund, Management and Stewardship Plan.

³⁰⁹ Ibid.

 $^{^{310}}$ Town of Southold (2008). Land Preservation Department, Community Preservation Project Plan

 $^{^{311}}$ Ibid.

³¹² Town of Southampton (2005) Community Preservation Fund, Second Project Update

and freshwater wetlands were also targeted in significant amount for acquisition. Many areas targeted for acquisition are coastal resilience related, such as the high priority Bullhead Bay, an area of tidal marshes, oak-hickory forests and spring-fed maple and tupelo swamps. The town's strict wetlands law also compliments the land acquisition strategy which includes more than 1,000 wetland parcels that meet consideration for acquisition.



Figure 10 - Example of development that used cluster zoning in Scarborough, Maine

Other traditional planning tools are often used in the service of preventiontype adaptations. Cluster subdivision ordinances, such as that in Scarborough, Maine, can be used to protect hazardous and ecologically sensitive land. The purpose of the law is to "conserve and protect the town's freshwater wetlands, watercourses, farmlands, open space and natural featrs, while enabling more flexibility for residential developments." ³¹³ The town requires projects cluster developments in three zoning districts, RFM, RF and R-2, when applying to develop multifamily housing, for properties over an acre, or when the property is comprised of 20% or more as wetlands or shoreland zone.³¹⁴ One example of implementation of the law was in the shorefront community of Pine Point. Through a developer agreement, the town was able to preserved oceanfront dunes in exchange for allowing clustered higher density lots.

Scarborough also utilizes the broad prevention strategy of a residential development limit and charges impact fees, which slowed growth to 125-150 units per year.³¹⁵ Most of this growth, due to the plan and conservation mechanisms in place, took place out of the floodplain and the immediate coastal zone of the town. The plan categorizes the three historic summer colonies of Pine Point, Prouts Neck and Higgins Beach as part of the "limited growth area."³¹⁶

³¹³ Scarborough, Maine Comprehensive Plan, Sec. VIII (A). (2006)

³¹⁴ Ibid.

³¹⁵ Ibid. 1-2.

³¹⁶ Ibid.

New Castle County, Delaware also has in place a model ordinance which utilizes traditional planning tools including setback and use regulations. It describes the Unified Development Code as providing "100% protection of floodplains, wetlands, riparian buffers and Class A wellhead water resource protection areas, as well as protection of various other natural resources which indirectly affect the quality of our water."³¹⁷ The code was further amended in 2003 by the Environment First Ordinance to further protect natural resources and allow flexibility in subdivision design to promote more environmentally sensitive development.³¹⁸ The goal was to not allow degradation of water quality, to encourage open space linkages, and to improve maintenance requirements for homeowners associations.

The code prohibits development in any floodplain with few exceptions that include site design standards to minimize debris trapping and 18 inches of freeboard. It only permits field crops, orchards, pastures, ball fields, fishing areas, natural areas and trails.³¹⁹ The code also defines Riparian Buffer Areas as 100 feet on either side of perennial or intermittent streams, lakes, and tidal wetlands. ³²⁰ Revegetation is required when development occurs in and around riparian buffer areas. These provisions apply to new construction only.

³¹⁷ New Castle County Department of Transportation. *NPDES Planning*. http://npdes.nccde.org/planning.html

³¹⁸ New Castle County, Del. Code, Ch. 40, Art. 4.

³¹⁹ New Castle County, Del. Code Ch. 40 Art 10.

³²⁰ New Castle County, Del. Code Ch. 40 Art 10, Sec. 313, 316, 317

Reconstruction or repair of non-conforming structures is permitted, pursuant to specific standards specified in the code, including elevation of the structure 18 inches above base flood.³²¹ The code also provides an exception for brownfield sites to encourage redevelopment of contaminated land.

5.3.3. Procedural

Procedural adaptations, defined as projects that generate information, such as studies, mapping exercises, administrative or educational programs, or those projects that incorporate that information into plans or other administrative or legal processes, were most common of the IPCC strategies. The largest number of strategies (52%) found were of this type.

Examples include studies, pilot projects or climate change plans. They often result in stand-alone documents that issue recommendations. Many of these projects are collaborative efforts with multiple partners including universities, state coastal management agencies and NGOs. Examples include the Greenwich Township, N.J. Coastal Community Vulnerability Assessment Tool and the Climate Change Adaptation Project led by the Consensus Building Institute, the Massachusetts Institute of Technology and the National Estuarine Research Reserve System, in Barnstable, Massachusetts and other New England towns. Some projects of the procedural type incorporate climate change into existing plans and procedures. 20% of the actions we inventoried involved incorporating climate change or sea level rise into another plan. The most common actions were to incorporate climate change into comprehensive/land use plans and hazard mitigation plans. Although we only found a few examples, some towns also incorporated climate change into a unique plan, such as Barnstable, Massachusetts, in its Coastal Resource Management Plan for the Three Bays and Centerville River Systems.³²²

An example is Guilford, Connecticut, which participated in a Nature Conservancy and Yale University project called the Community Coastal Resiliency Plan.³²³ It subsequently incorporated the information generated from the resiliency plan into its Comprehensive Plan of Conservation and Development as well as its Hazard Mitigation Plan. Another example of such a project is the Delaware Vulnerability Assessment and Coastal Resiliency Action Plan. The City of Lewes received funding from NOAA's National Sea

³²² Town of Barnstable, Mass. (2009). Coastal resource management plan for the three bays and centerville river systems, Sec. 6.3.3.1. Retrieved from

<u>http://www.townofbarnstable.us/ComprehensivePlanning/Adoptedplans/coastalresourceplan.</u> <u>pdf</u>

³²³ Milone & MacBroom, Inc. (2012). Town of Guilford Community Coastal Resilience Plan Risk and Vulnerability Assessment Report. Retrieved from <u>http://www.ci.guilford.ct.us/pdf/coastal-resilience-plan-</u> Risk%20and%20Vulnerability%20Assessment%20Report.pdf Grant climate change initiative to engage in a participatory process to develop a hazard mitigation and climate change plan in one document.³²⁴ This has created a model for such planning for the future, since hazard mitigation planning is already commonly done as required by the NFIP and other federal law.

5.3.4. Protection

Protection is defined as actions taken to protect land from inundation by rising seas and storm surge, such as elevating sea walls or beach nourishment. Protection projects represented 6% of projects found in the sample, which was second least-common. Protection actions include green infrastructure, including flood barriers such as living shorelines and dune systems and gray infrastructure strategies such as elevating bulkheads, building higher sea walls, and new pump stations above expected flood stage.

Poquoson, Virginia is constructing all new pump stations are constructed above the 100-year flood elevation. The city also installed a system that allows the pump stations to notify the city when any of 16 events occur, such as when the water level rises, power is interrupted, or the pump fails. The city has also

³²⁴ City of Lewes, Del. (2011). The city of Lewes hazard mitigation and climate adaptation action plan. Retrieved from

http://www.ci.lewes.de.us/pdfs/Lewes Hazard Mitigation and CLimate Adaptation Action Plan_FinalDraft_8-2011.pdf

installed permanent generators or has mobile generators available to supply all 29 pumping stations. The city also mandates that all new utilities built below the 100-year flood elevation have watertight manhole lids. In Norfolk the city is taking on a number of protection projects that will increase its resilience. For instance, the city is constructing a new living shoreline, raising the height of a bulkhead up to two feet, and installing a mobile pump.

The Town of Southampton, New York has taken the unique initiative to establish beach erosion control districts that are separate taxing authorities established to fund beach and dune restoration in specific neighborhoods. Two years ago it established one such district in Sagaponack, called the Sagaponack Beach Erosion Control District.³²⁵ Since then, the town board and a consultant have prepared baseline surveys, evaluated shoreline erosion along the beach, developed alternate plans for beach restoration, and commenced the permitting process for a beach restoration project that will add 1,035,000 cubic yards of sand. The project includes the development of a comprehensive dune preservation and restoration plan as well as \$11 million in projected capital improvements. The project is billed to improve recreation by widening the beach as well as to preserve the community by preserving the existing dune line and reduce flooding risk.

³²⁵ Toy, E. (2012, July 25). SouthamptonSouthhampton Town to Address Beach Erosion. The Independent. Retrieved from <u>http://www.indyeastend.com/Articles-News-i-2012-07-25-103157.113117-Southampton-Town-To-Address-Beach-Erosion.html</u>


Figure 11 - Bowers, Delaware, repetitive loss home (left) was converted into the Main Street Park (right) demonstrating an effective retreat project

Retreat is defined in the literature as allowing for existing coastal ecosystems to shift landward. In our sample, examples include buyout of repetitive loss properties and transfer of development rights. These were the rarest type of adaptation found, representing only 3% of projects. Types of retreat actions include buyouts and creation of parks, rezoning to reduce development in vulnerable areas, establishment of setbacks and minimum lot sizes, and prohibition of certain uses. An example of an innovative retreat project in our sample comes from Bowers Beach, Delaware. The town purchased a repetitive loss property and converted it into "Main Street Park" with a bocce ball court. Bowers is also planning to rezone the town to permit commercial development in a less flood-prone neighborhood than its existing location. Another rather unique retreat program is found on Cape Cod. The Town of Barnstable, Massachusetts adopted а land use strategy it calls "undevelopment" or property reclamation.³²⁶ The town purchases properties and undevelops them for a variety of purposes, including traffic mitigation, resource protection or property remediation. Six properties in Hyannis, Centerville and Cotuit have been undeveloped through the strategy, including a former motel on Craigville Beach Road in Centerville, which was acquired and demolished to preempt more intensive development in the vulnerable location. The property is now used as the town's coastal plant nursery. In addition, a Gulf gas station on Main Street in Hyannis was purchased and razed to serve as a pocket park that uses phytoremediation.³²⁷

Some types of laws, such as expansion of coastal setbacks, or redefinition of mean high water could be used to effect retreat, although in practice these tools have mainly been used for prevention purposes. The rarity of the use of retreat tools likely owes to their high capital cost as well as political and legal challenges.

 $^{^{326}}$ Town of Barnstable, Mass. Open Space Plan, p. 18. 327 Ibid. p. 19

5.4 PRACTICE TYPE



Figure 12 - Distribution by practice type



Figure 13 – Practice type summary data

The adaptations were categorized by seven different practice types: Administrative, Capital Investment, Education/Outreach, Laws, Plans, Policies, and Studies/Pilot Projects. The distribution of practice tool strategies by frequency of adoption is depicted in Figure 9 and 10. Laws were the most common, representing 41% of actions. Plans were second most common, with 25% of adaptations falling into this category. 18% of actions were classified as studies/pilot projects. Capital investment represented 7% of actions, and policies 4%. Administrative actions were second least common (4%) and education/outreach least common, at 1%.

5.4.1. Laws

Laws were the most common type of practice tool, representing 41% of those found. Laws, which at the local level are often called ordinances or bylaws, create mandatory expectations of compliance. Laws differ from other adaptations in that they are enforced by city administrative staff and the courts and result in some type of penalty for failure to comply. In the context of climate change adaptations, they most often apply to building and zoning codes. Laws could be used to implement any one of the five adaptation strategies.

5.4.2. Plans

Plans are process-driven documents that serve as guidance for future-decision making, and they represent 25% of the adaptations found. The two major types of plans found in our sample were Comprehensive Plans and Hazard Mitigation Plans. Examples of plans include comprehensive plans, hazard mitigation plans, and alone climate change adaptation plans. Other examples include a Comprehensive Waterways Management Plan in Hampton, Virginia, a Land Protection Plan in Hull, Massachusetts, an Open Space Plan in Little Silver, New Jersey, Local Waterfront Revitalization Plans, found in all our towns in New York, and PlaNYC, a comprehensive sustainability plan.

5.4.3. Studies

Studies and pilot projects often result in stand-alone documents that issue recommendations, and are sometimes woven into a climate change plan. They represent 18% of adaptations found, and are often collaborative efforts with multiple partners including universities, state coastal management agencies and NGOs. They usually employ modeling to determine risks and often include a vulnerability assessment. Examples include the Greenwich Township, N.J. Coastal Community Vulnerability Assessment Tool and the Climate Change Adaptation Project led by the Consensus Building Institute, the Massachusetts Institute of Technology and the National Estuarine Research Reserve System, in Barnstable, Massachusetts, and other New England towns.

5.4.4. Administrative Actions

Administrative actions are those activities taken by a government that involve process, and represent 4% of adaptations. Examples include Hampton, Virginia's appointment of a waterways grants manager, Lewes, Delaware's establishment of a permanent mitigation planning team, a FEMA cooperative mapping project taken on by New Castle County, Delaware.



Figure 14 - Portsmouth, VA's floodplain management plan outreach flyer

Although only two projects made it into our sample (1% of actions), these projects can be big in impact. Many towns do required outreach as part of their climate, comprehensive or flood mitigation planning processes, but the town of Greenwich, Connecticut and Portsmouth, Virginia have exemplary outreach efforts that go far beyond required minimums. They were rated an average effectiveness of 4/5.

The town of Greenwich, Connecticut has been conducting outreach, using maps generated by the town's GIS, to educate homeowners about coastal flooding risks. Portsmouth, Virginia is conducting flood education outreach on local cable TV, rented billboards, and sends out postcards in order to disseminate information. The city also prepared and posted an interactive floodplain map on its web site and is developing strategies and identified funding sources to assist property owners looking to flood proof their buildings. Portsmouth is also reaching out to the 60% residents that rent their homes. It is also using its GIS to identify vulnerable homes near existing repetitive loss properties, since FEMA programs do not address residents that do not have a mortgage. These education and outreach programs can have the effect of empowering individual property owners to take action even in the absence of explicit governmental programs or regulations.

5.4.6. Capital Investments

Capital investments (8% of adaptations) most often involve financing the construction or maintenance of a green or gray infrastructure project. Examples include Bowers, Delaware which bought out a repetitive loss property and converted into Main Street Park with a bocce ball court; Poquoson, Virginia's construction of all new pump stations above the 100-year flood level; Little Silver, New Jersey's installation of a flood gauge warning system; Scarborough, Maine's establishment of an open space fund; and Ocean City, New Jersey's self-funded maintenance of its beach renourishment and protection project.

5.4.7. Policies

Policy adaptations, representing 4% of our sample, are wide-ranging in scope. They include executive orders or administrative actions, such as the adoption of engineering standards for public works that incorporate climate considerations in Groton, Connecticut, Poquoson, Virginia's 4.5 ft. elevation standards for new roads, the City of New York Department of Parks and Recreation's inclusion of climate adaptation measures in their high performance guidelines describing best practices for planning, design, construction and maintenance of city parks, and the establishment of a coastal advisory committee in Marshfield, Massachusetts.

5.5. INCORPORATION OF CLIMATE CHANGE



Figure 15 - Distribution of projects that explicitly incorporated climate change

This category describes whether a project was designed to be responsive to evidence of a changing climate or sea level rise. Plans are one type of adaptation that frequently incorporate climate change, although the extent of that incorporation varies extensively. The following municipalities all incorporated climate change into their comprehensive plans: Barnstable, Massachusetts, Crisfield, Maryland, Greenwich, Connecticut, Guilford, Connecticut, Hampton, New Hampshire, Marshfield, Massachusetts, Norfolk City, Virginia, Ogunquit, Maine, Poquoson, Virginia, and Sea Isle City, New Jersey.

In Poquoson, Virginia, for instance, concern about climate change and sea level rise is expressed in its plan in an aspirational manner, but there is no specific implementation into policies. The plan discusses a "policy development for sea level rise" and recommends that policies be developed, such as those that minimize the fill of land, maximize preservation of existing vegetation and address elevating roadways, after the state department of natural resources issues a report on climate change.³²⁸

Hampton, New Hampshire incorporated sea level rise and climate change in a similar aspirational manner in its Hampton Beach Area Master Plan (2001).³²⁹ The plan states that recent analyses suggest sea level is rising 1/8 inch a year, and suggests a number of challenges it will cause, including "inundation of ocean water into low-lying areas...storm surge and wave runoff [which] is likely to cause more of a problem than inundation since the built areas will be affected by storm waves."³³⁰ The plan cites inundation of ocean water into low-lying areas, erosion of beach cliffs, loss of low-lying land, loss of sediment along beachfronts, salt intrusion into aquifers and surface waters, and higher water tables.³³¹ The plan mentions challenges such as elevation standards being based on static floodplain designations without considering sea level rise, and suggests future adaptations, such as regulations to enhance flood controls, stricter building codes in flood areas, and similar actions that change the types of structures that are built near or in high-velocity wave areas.³³²

³²⁸ Poquoson, Va... (2008) 2008-2028 Comprehensive Plan, p. 8-15.

³²⁹ Hampton, Va. (2001), The Cecil Group, Inc. Hampton Beach Area Master Plan.

³³⁰ Ibid. p. III-104

³³¹ Ibid.

³³² Ibid.

Laws rarely incorporate climate change explicitly because they tend to prescribe action that must be clear and enforceable, such as number of feet of freeboard or a setback standard. Nevertheless, there are examples of a few codes that that do incorporate climate change explicitly. The towns of Barnstable and Hull in Massachusetts both incorporated sea level rise into local bylaws.

Barnstable recognized that two critical areas of town, the Craigville Beach area and the Centerville Village Center, were at particular risk to coastal flooding. It enacted a special zoning ordinance as part of the designation of the Craigville Beach area as a District of Critical Planning Concern. Massachusetts has strict state laws which normally forbid local governments from deviating from state codes. Designating a District of Critical Concern, however, grants Cape Cod towns the authority to supersede state law with respect to certain regulations, including requiring freeboard of structures above state minimums.

The purpose and intent section of the town code explicitly states:

As the entire complex of coastal wetland resources moves landward due to relative sea level rise, the Craigville Beach area's coastal floodplains immediately landward of salt marshes, coastal beaches, barrier beaches, coastal dunes, and coastal banks require special protection.³³³

The law is intended to protect the character and historic development patterns, improve natural resources including barrier beach and coastal water quality,

³³³ Town of Barnstable Town Code §240-131.1

protect human life and property from flooding, and preserve the natural flood control functions of the floodplain.³³⁴ The law requires structures in the V zone and the A zone to be elevated to two feet and one foot above base flood elevation respectively. ³³⁵ The special district, which was also concerned with preservation of views and community character, specifically allows for waiver of height limits when necessary to elevate a structure.³³⁶

Hull, Massachusetts also enacted an ordinance requiring the consideration of climate change that is concerned with both mitigation and adaptation objectives. Mitigation objectives encourage mixed uses and a pedestrian and bicycle-friendly community, lessen sprawl and reduce greenhouse gas emissions. The law also states its purpose to protect barrier beaches and dunes that provide storm and flood protection and wildlife habitat, as well as to incentivize development that can withstand "increased flooding and frequency and intensity of storms caused by climate change."³³⁷ It further states that the law will "protect persons and property from the hazards that may result from unsuitable development in areas subject to flooding, extreme high tides, and rising sea level."³³⁸ Hull's code also requires its planning board to consider sea

³³⁴ Ibid.

³³⁵ Ibid. §240-131.7 (C)

³³⁶ Ibid. §240-131.5 (C)

³³⁷ Ibid.

³³⁸ Ibid.

level rise in its site plan reviews.³³⁹ According to the town, the purpose of these amendments was to ensure that applicants provide information about flood zones and consider the current and future potential for flooding, and have the Planning Board review the adequacy of plans to prevent flood damage. The code specifies design guidelines the planning board may consider in rendering a decision, including "Protection against flood damage on site and protection against flood impacts to adjoining properties, taking into consideration current conditions and the potential for future sea level rise."³⁴⁰

³³⁹ Hull Town Code, Art IV., Sec. 40. Site plan review applies to subdivisions three lots or greater, multi family buildings of three units or more, and changes to buildings larger than 5,000 square feet.

³⁴⁰ Ibid. Sec. 40-4

5.6. ENFORCEMENT STRENGTH



Figure 16 - Distribution of projects by enforcement strength



Figure 17 - Projects by enforcement strength, effectiveness, costs, and frequency

The literature supports the notion that most climate change planning results in little discernible action. Wheeler studied climate change plans in all states with climate planning documents and all cities of over 500,000 that are members of the Cities for Climate Protection campaign, and found that they mostly lacked the actions and political and institutional commitment needed to mitigate or adapt to climate change.³⁴¹ To determine the extent to which this was true in our sample of actions, we characterized each adaptation by enforcement strength. Actions were categorized from strongest to weakest as mandatory, implemented, incentives, permissive, advisory, or proposed.

Mandatory actions, the strongest enforcement strength, require compliance under penalty of law, such as building codes, subdivision regulations, or zoning codes. Implemented adaptations do not require action of others or later in time but rather were directly implemented by the municipality. Most often these are infrastructure projects implemented through capital budget expenditures. Incentives is defined as actions that grant some benefit or provide some additional value to the adopter, such as waiving building permit fees for homeowners that elevate above minimum flood elevation. Permissive actions are those that allow a property owner to take some action that is otherwise prohibited, such as height limit waivers. Advisory actions produce recommendations or guide future decision making, such as most studies and plans. In most states, comprehensive and master plans are also simply advisory. Amongst North Atlantic states, Rhode Island, Massachusetts and Delaware require implementation of comprehensive plans, and those states

³⁴¹ Wheeler, "State and municipal climate change plans"

are also the only states in the northeast that require comprehensive planning.³⁴² In these states, therefore, if a comprehensive plan incorporates climate change, it is classified as a mandatory action. Proposed is the weakest strength. Proposed actions are those that are being advocated but have not yet seen formalization. Actions in this category were limited to those being adamantly championed by elected officials as expressed during interviews.

The chart in Figure 12 depicts the frequency of enforcement impacts of those that were rated. Mandatory actions were the most common type and represent 42% of adaptations. Advisory adaptations, which typically issue recommended actions, represent 39%. 12% of adaptations do not require or recommend others to act but are rather directly implemented. 5% of adaptations were permissive. The least common, representing 1% of adaptations respectively, were of the proposed and incentive type.

The chart in Figure 17 depicts enforcement strength categories on the X-axis, arranged in order from weakest to strongest: Advisory, Permissive, Incentive, Mandatory and Implemented. Mandatory and implemented are of a different character however and one cannot be said to be stronger than the other. Also note that proposed projects were omitted from the chart because there were

³⁴² American Planning Association. (2002). Growing smart legislative guidebook-model statutes for planning and the management of change (No. 39157). HUD USER, Economic Development.

too few examples and the responses were highly skewed. Of those types with greater than one example, implemented and mandatory projects were rated as most effective, and permissive projects were least effective. Mandatory projects were rated most replicable and permissive projects least replicable. Mandatory projects were lowest cost, averaging \$30,000, whereas implemented projects were most costly, averaging more than \$120,000.

5.6.1. Advisory

Projects that resulted in recommendations, or advisory actions, were the second most common in our study, representing 39% of adaptations. Almost all studies and plans result in advisory actions. Examples of such projects include the Maryland Coast Smart Rising Sea Level Guidance Study conducted in Somerset and Worcester County and the Coastal Community Vulnerability Assessment Tool in New Jersey.

Although they are simply advisory, such plans can be invaluable in informing communities about the potential risks of climate change and motivate them take subsequent action. The Worcester Sea Level Rise Response report modeled sea level rise for the years 2025, 2059 and 2100 and used three scenarios: steady state, average accelerated and worst case.³⁴³ These scenarios allowed the county to understand projected impacts from extrapolated existing

³⁴³ Worcester County, Md. "Sea Level Rise Response Strategy." (2008).

conditions to the most drastic potential. The report includes a vulnerability analysis, potential response options, and a chapter on priorities for sea level rise response, including setting criteria for prioritization and a ranking matrix. The report makes specific suggestions for application of the adaptation principles to Worcester and describes methods for integration with existing codes and plans. Worcester's sophisticated planning already limits sprawl by maintaining compact communities surrounded by agricultural and natural lands. This strategy comports well with projected sea level scenarios, since the plan reports that 30% of the property parcels projected to be 100% inundated by the worst case scenario in 2100 do not currently house any structures.³⁴⁴

5.6.2. Mandatory

Adaptations that mandate compliance represent 42% of our sample. Most adaptation actions that have a mandatory effect are laws, such as building codes, subdivision regulations, or zoning codes. Examples of typical mandatory actions include freeboard requirements, wetland buffer regulations and flood management ordinances. Most types of plans, such as hazard mitigation plans and floodplain management plans, by themselves do not create mandatory action. Some, however, including Local Waterfront Revitalization Plans in New York State and Hull, Massachusetts' Beach Management Plan do create mandatory action.

³⁴⁴ Ibid., 2-8.

5.6.3. Permissive

Permissive actions are those that allow a property owner to take some adaptation action that is otherwise prohibited. Permissive actions represented 4% of the sample, and they rated as least effective of all enforcement strengths. The most commonly adopted permissive action is height limit waivers for elevated structures. Three communities – Hull and Barnstable, Massachusetts as well as Lewes, Delaware, adopted height limit waivers. These can be automatic or can require approval of municipal government.

Lewes does not have a mandatory freeboard requirement, but it has adopted a unique height limit exemption permitting heights of three feet greater than otherwise allowed within its coastal high hazard area flood zone. This allows homeowners to elevate their structures without running afoul of regulated height limits.³⁴⁵

Other examples of permissive actions include most Transfer of Development Rights (TDR) programs. TDR programs in East Hampton New York, Southold, New York, Southampton, New York, as well as in York, Maine, allow for homeowners to optionally transfer their rights to other sites and preserve vulnerable wetlands or coastal shorelines. Overlay zones also sometimes refer

 $^{^{345}}$ Lewes, Del. City Code \$197-55

to permissive actions, but they can also be mandatory. Overlay zones that are of the permissive type are sometimes referred to as "floating" zones.

Hull recently passed an overlay zone provision that is permissive.³⁴⁶ The code entitled "Adaptive and Resilient Building and Open Space" permits the planning board to allow building heights up to 40 feet above a nonhabitable lowest floor, provided the space is used as a "market hall."³⁴⁷ A market hall is defined as a traditional open market for temporary commercial uses that contributes to the economic and social activity of the district.³⁴⁸ Suggested uses include farmers markets, art exhibition or performance spaces and outdoor cafes. Parking is allowed but cannot occupy more than fifty percent of the space. The section also prohibits mechanical, HVAC equipment, and generators on the lowest floor and requires them be elevated on the roof or upper stories. The code also requires underground utility lines and submersible HVAC equipment,³⁴⁹ incorporation of green building standards,³⁵⁰ and incorporation of landscape features to provide storm and flood protection.³⁵¹

³⁴⁶ Hull, Mass. Town Code Art. X.

³⁴⁷ Ibid. Sec. 12.2.3

³⁴⁸ Ibid. Sec. 12.3.2

³⁴⁹ Ibid. Sec. 12.3.6

³⁵⁰ Ibid. Sec. 12.3.8

³⁵¹ Ibid. Sec. 12.3.9

5.6.4. Incentives

Very few adaptations (1% of the sample) use incentives to encourage adaptive behavior. This is surprising, since, when posed with the prospect of mandating changes to adapt to climate change, many interviewees that seemed skeptical had a positive reaction to the idea of incentivizing such changes. This indicates that there is a gap between knowledge and practice, or more likely, both knowledge and practice.

One traditional tool that can be used to incentivize adaptive behavior is zoning bonuses. Some towns uses bonuses to incentivize cluster or transfer of development rights programs. Hull's code also has a cluster provision which provides for a density bonus of 25% for subdivisions of a minimum of ten acres and potentially could be used to prevent development of floodplains and wetlands.³⁵² Ocean City, Maryland's beach transfer zone project mandated the use of the TDRs, but also provided a 25% FAR bonus to the receiving property to encourage a market for the transfer rights.

Hull also created a unique incentive-based program to encourage freeboard. The town offered a \$500 credit towards building permit fees for builders and owners of existing and new residential and commercial structures that are

³⁵² Hull, Mass. Code Sec. 43

built two feet above the highest state flood zone minimum height elevation requirement.³⁵³ In the first two years of implementation of the program, ten permits for new construction and four permits for elevation of existing development have gualified for the credit.

5.6.5. Implemented

Some adaptations did not require action of others or later in time, but rather were directly implemented by the municipality. Implemented adaptations represented 12% of the sample. These were most often engineering or infrastructure projects such as Little Silver, New Jersey's installation of a flood gauge warning system, storm water upgrades in Norfolk, Virginia, and pump station improvements and elevation of bulkheads, as done in Poquoson and Portsmouth, Virginia. This category also included retreat projects, such as Bowers, Delaware purchase of a repetitive loss property and conversion into a park.

5.6.6. Proposed

A small number of adaptations (1%) were included even though they were only proposed and did not result in any discernible action. These were both in Bowers, Delaware, where the mayor emphatically indicated his town's aggressive plans for action to protect itself from sea level rise and climate

³⁵³ Ibid. Sec. 12.2.1

change. Bowers is planning to use a retreat strategy to relocate its downtown commercial district to make it less vulnerable to coastal flooding. The business district is at significant risk due to the deteriorated condition of the town's seawall. The Mayor explained the situation: "Because the seawall is deteriorated we are faced with a choice—do we get the seawall fixed or do we run for the hills and let everything go?"³⁵⁴ He explained that the town is "deciding to try to get the seawall fixed...understanding that that will mitigate the problem...but it won't solve the problem for the future."³⁵⁵ To ensure the town has a viable business district, he said they plan to move the downtown to a location less impacted by flooding, and "to look at what kind of construction we can require so that it will last half a generation."³⁵⁶ The Mayor explained they are planning on rezoning the current commercial district to residential, and rezoning a part of town that is currently zoned residential on higher ground to commercial.³⁵⁷ Although the plan would not move the commercial distinct overnight, it would do so as non-conforming uses are phased out over time.

Overall, mandatory and advisory strengths were most frequently adopted, and incentive and permissive adaptations were least frequently adopted. Proposed and incentive projects were least frequently adopted. Of projects with an n of

357 Ibid.

³⁵⁴ In person interview with Mayor of Lewes, Del. (Aug. 09, 2012)

³⁵⁵ Ibid.

³⁵⁶ Ibid.

greater than 5, implemented projects had the highest average effectiveness rating, followed closely by mandatory projects. Projects that were advisory in nature were rated, not surprisingly, as somewhat less effective than mandatory and implemented projects. Permissive projects were rated as least effective of all enforcement strengths.. Incentive projects were rated as most effective of all, but with an n of one, this is in no way could be considered a large enough sample to draw conclusions from.

5.7. INDEPENDENCE OF ACTION



Figure 18: Distribution of projects based on independence of action

As part of the initial screening for locally-driven activities, all adaptation actions had to meet the standard as a locally-driven activity. However, the activity could either supersede or go above a minimum, standard, or required action, or the activity could be a unique endeavor on the part of the municipality. The action could also have been a voluntary partnership with non-profits, other governments, or universities. These partnerships were also classified as unique if they were independently created without an underlying minimum or standard.

About three-quarters of the actions found in our sample were unique and onequarter were above required minimums. Examples of actions that were unique include cluster zoning in Scarborough, Maine or the use of Transfer of Development Rights to create and protect dunes in Ocean City, Maryland and Southampton, New York. Other unique actions include those such as establishment and installation of a flood gauge warning system in Little Silver, New Jersey and the drafting of a sea level rise plan in Crisfield, Maryland.

Examples of actions that supersede or go above required standards include setting freeboard standards above a one foot minimum required by the state, incorporating climate change into a comprehensive or hazard mitigation plan, or enacting zoning, such as Hampton, New Hampshire, did, with wetlands setbacks that are greater than those required by the state.

The finding that the majority of the actions were unique comports with the notion that local governments are taking initiative, and the most common way that they are is by forging new roads in laws, policies, partnerships and plans to address climate adaptation. States have been latecomers to the climate adaptation arena, and when the data was collected in 2012, states did not have a significant number of relevant laws or policies. However, this is changing now that they are beginning to wake up to the urgency of action.

5.8. SURVEY FINDINGS

This study proposed creating a method to analyze adaptation solutions to aid prioritization and the development of cost-benefit models, by measuring the potential benefits of various adaptation actions. To measure the benefits and costs of these adaptations more precisely than could be achieved with interview data, a follow up internet survey was conducted. The survey was administered to all municipalities that participated in the initial interviews and plan reviews. The survey questions were validated through expert review by the NOAA panel as well as pilot testing. All 34 municipalities and/or counties responded to the survey, each responding to 9 questions about their adaptations. Survey responses were recorded for a total of 134 adaptation actions (n=134). The survey consisted of seven multiple choice questions and two open response questions.

Their assessment criteria are meant to apply to adaptations taken at different scales and institutions, from national governments to private corporations. As a result, some aspects of their typology were very difficult to measure in questions directed to municipal officials. Specifically, equity was not measured as most of the actions do not address distributional issues. In addition, efficiency would be challenging to measure through a survey. Their construct of legitimacy is also difficult to measure, but we did choose to measure replicability, which is a measure of the extent to which the project is acceptable to those in the community and perceived acceptability in other communities. Data was also gathered on primary motivations for the actions and a question on improving effectiveness was also asked.

This question verifies the adaptation meets criteria for inclusion in the sample.





Figure 19 - Distribution of projects by cost to municipality

A large percentage of adaptations were either no or low cost. 21% of projects reported no separate identifiable costs at all, and another 18% were under \$1,000. 18% of projects cost more than \$100,000 but less than \$1 million. Only 8% of projects were reported in the highest cost category. This was not surprising since the survey specifically sought out low cost adaptations.

Question 1 of the survey asked respondents to indicate the cost *to the town* to participate in the project. Multiple choice answers were provided due to challenges with obtaining exact figures of costs from municipalities encountered during the interview phase. Options were 1) Zero; 2) Very Low, less than \$1000; 3) Low, less than \$10,000 and greater than \$1,000; 4) Medium, less than \$100,000 but greater than \$10,000; and 5) High, greater than \$1,000,000.

The variety and effectiveness of so many adaptations with very low costs are a very significant finding, since it is often assumed that climate adaptation is prohibitively expensive. Many types of regulatory adaptations are nearly costless, including most zoning and building codes. Passing a freeboard requirement or cumulative substantial improvement ordinance is nearly costless to the municipality, since they are enforced by routine building and code inspection.

An example of a simple procedural adaptation which is nearly costless, but can have powerful effects, is Guilford, Connecticut's Formal Resolution Recognizing Climate Change. The Guilford Board of Selectmen passed a resolution in 2007 recognizing climate change. ³⁵⁸ It directed town departments, boards, and commissions to "formally consider impacts of this phenomenon on planning, management, procurement and budgetary decisions, and regulations relating to the objective of reducing greenhouse gas emissions, and mitigating negative effects projected to evolve from climate change."³⁵⁹

Often, climate change can be incorporated into an existing document or process for very little additional cost over what the document would cost anyway. For instance, Brewster, Massachusetts incorporated sea level rise into its Hazard Mitigation Plan. Sea level rise is addressed in the hazard mitigation plan as

 ³⁵⁸ Guilford, Conn. Resolution of the Board of Selectmen. Feb. 5, 2007.
³⁵⁹ Ibid.

one of the nine significant hazards facing the town. Sea level rise is described in the plan as potentially causing shoreline change, long-term coastal erosion, and flooding.³⁶⁰ Because it effects these other risks, which are analyzed as separate but interrelated threats, sea level rise is weaved throughout the plan and is discussed as an exacerbation of other risks. In the natural hazards ranking, sea level rise is mentioned under flood hazards along with coastal storm surge, storm tides, wave action, and erosion. It is also mentioned under the heading of geologic hazards along with shoreline erosion, long-term shoreline change, storm-caused change, and landslides of coastal banks. Sea level rise is also predicted to have exacerbating impacts on the problem of shoreline erosion. Although not specified as a separate threat, the list of nine hazards is followed with the following language concerning climate change:

In addition climate change can exacerbate these events, causing impacts such as increased frequency and intensity of heavy downpours. Rising sea levels are expected to continue while new impacts will likely emerge, such as increased intensity of hurricanes. This could result in an increase in storm surge.³⁶¹

The hazard plan suggests specific mitigation actions, such as a suggestion that the town continue to participate in marsh restoration infrastructure projects to reduce the threats of sea level rise, erosion, fires, and floods. The plan also projects that conducting a hazard mitigation educational workshop for coastal and riverfront landowners and contractors will mitigate sea level rise as well as floods, wind, and erosion. Some adaptations, such as the 2% real estate

³⁶⁰ Brewster, Mass. Hazard Mitigation Plan (2001).

³⁶¹ Ibid., 9.

transfer tax in East Hampton, Southampton, and Southold, New York are revenue-generating. Costs, however, are also related to size and capacity of the local government. For instance, nearly all of New York City's adaptations, including PlaNYC, its newly passed green zoning code (Zone Green), which includes provisions to allow relocation of utilities to rooftops in flood prone areas, the NYC Panel on Climate Change and Report, and its Local Waterfront Revitalization Plan, all have high costs over \$1 million. But similar projects in smaller localities, such as East Hampton, New York's LWRP, only cost it between \$10,000 and \$100,000.



5.8.2. Adaptation Motivations

Figure 20 – Adaptation Motivations

Question 2 asked respondents to identify the most important motivation behind the project. Answer options included 1) funding was available, 2) to earn CRS credits, 3) elected officials advocated; 4) to protect the community; 5) for environmental resource conservation; 6) to reduce development pressure, 7) other.

We found that many actions that are climate adaptive had other sources of motivation and significant co-benefits. Protecting the community was by far the most significant motivation, and nearly 70% of all adaptations were for this purpose. This highlights the fact that safety and security is still the most important driver of climate change adaptive actions. The second most frequent response was environmental or resource protection, said to motivate 35% of adaptations. Responding to constituent concerns was the next most frequent response (25% of adaptations) indicating that citizen demand for action is a significant factor.

Notably, only 13% of actions were motivated because funding was available. This is also significant since it bolsters the finding that many climate adaptive actions being taken by municipalities are either low or no cost, and that even for those that were not no cost, that external funding was not a significant motivator of action.

While we know that CRS is an important factor in municipalities that take the program seriously, and likely will become more so in the future with rising insurance rates, in our sample, CRS was not a significant motivation factor, only an issue in 8% of actions.

These results generally comport with the literature. Hughes conducted a metaanalysis of climate adaptation planning and looked at motivations across more than 50 studies.³⁶² She found the most significant motivation was experience with hazards. Demonstration of leadership was also a significant source of motivation, while community pressure and funding were found to be weak motivators. She said:

[T]here was little evidence that urban climate change adaptation planning is happening in response to bottom-up demands; instead local governments are often developing mechanisms for engaging the public and generating interest in and support for adaptation planning.³⁶³

5.8.3. Effectiveness



Figure 21 – Distribution of effectiveness scores

Question 3 asked respondents to indicate how effective they believed the project was at reducing the community's vulnerability to climate change and

³⁶² Hughes, "A meta-analysis of urban climate change adaptation."

³⁶³ Ibid., 6.

sea level rise. Options for answering this question were based on a Likert scale from 1- (not effective) to 5- (very effective).

As is often the case with such scales the majority of the responses were in the middle. Only 3% reported the adaptation as a 1 - not effective, and 16% as a 5 - very effective. 40% of replies said the adaptation was 4 - highly effective and 26% said it was 3 - somewhat effective.

A limitation of this question is that it is uni-dimensional in that it only assesses effectiveness measurable by the municipality itself and is not concerned with external impacts.

5.8.4. Improving Effectiveness



Figure 22- What would make projects more effective (number of projects the response was chosen for)

Question 6 asked what respondents thought would make the project more effective. Multiple choice answers were provided including 1) funding, 2) education, 3) state or federal legal changes, 4) technical assistance, and an option for other. Education and funding were both seen as the most important methods of improving effectiveness, seen as assisting in more than 65 projects each. Technical assistance was seen as important in 40 projects, and state or federal legal changes mentioned in 26. This is somewhat in contrast to the findings with regard to motivations, which minimized the importance of external funding.

5.8.5. Replicability



Figure 23 - Distribution of projects by replicability score

Question 7 asked how replicable the projects were. Options for answering this question were based on a Likert scale from 1 (not effective) to 5 (very effective).

As Smith et al. 1995 highlight, climate adaptation measures should be feasible and able to gain support for adoption. We measured this criteria in a question about replicability, since the measure was presumably adopted in the subject jurisdiction, but it was important to understand the extent to which the measure is seen as feasible in other places. Less than 10% of adaptations were rated as poorly replicable. 70% were rated as highly or very highly replicable.


Figure 24 - Distribution of sources of external funding

Question 8 asked whether the projects received outside funding, and what the funding source was. Options included 1) NOAA, 2) FEMA, 3) State, 4) NGO or foundation, 5) Other, and 6) none.

The majority of the projects did not receive any type of external funding. Of those that identified a specifically enumerated funding source, state funding represented the largest share (13% of projects.) FEMA funded 7% and NOAA funded 5%. While the sample was specifically looking for low cost projects, it is still surprising that so many projects were completed without any external funding at all, demonstrating that local governments are finding resourceful ways to adapt to climate change without breaking the bank.

5.9. THE LOCAL ADAPTATION QUALITY INDEX

An adaptation quality index was constructed to gather an overall measure of the usefulness of the adaptations. The index was calculated by adding the values of the quantitative measures gathered in the follow up survey as follows:

QI = (Inv. Costs Rank) + (Effectiveness) + (Replicability) + (Incorporation of Climate Change)

Whereas, (Inv. Costs Rank) represents a number from 1 to 5 corresponding to the answer supplied by the survey respondents on the question indicating the total cost of the adaptation program to the municipality.

5 = \$0 to \$1000 4 = \$1001 to \$10,000 3 = \$10,001 to \$100,000 2 = \$100,001 to \$1,000,000 1 = Over \$1,000,001

(Effectiveness) represents a number on a Likert scale from 1 to 5, as replied by survey respondents, with 5 being most effective and 1 being least.

(Replicability) represents a number on a Likert scale from 1 to 5, with 5 being most replicable and 1 being least.

(Incorporation of Climate Change) represents a binary response – either 0 or 1

-0 if the adaptation did not incorporate climate change and 1 if it did.

5.9.1. Average Index Results

Rankings were averaged across different categories of adaptations and depicted in the charts below.

The chart below shows average rankings by Strategy type, either accommodation, prevention, procedural, protection, or retreat. Procedural adaptations rated as highest in overall quality, with an average quality score of 14.5. Prevention and protection strategies rated as lowest, with an overall quality ranking of 11. This comports with our general findings that procedural adaptations are seen as easier to implement, of lower cost, and more readily transferable than many other types of adaptations.



Figure 25 - Quality index average value of each strategy

Procedural adaptations rated as highest in overall quality, with an average quality score of 14.5. Prevention and protection strategies rated as lowest, with

an overall quality ranking of 11. This comports with our general findings that procedural adaptations are seen as easier to implement, of lower cost, and more readily transferable than many other types of ad -aptations.



Figure 26 - Quality index average value of each practice type

In the following chart, average index rankings are plotted for practice type, which are either administrative, capital investment, education/outreach, law, plan, plan/pilot project combination projects, policies, or study/pilot project. Projects that combined plans into a study or pilot project rated as having the average highest overall quality.



Figure 27 - Quality index average value count of each practice type

T-tests of independence were conducted to determine if the quality of the adaptations (as measured by averaging the adaptation quality index scores by category) is related to the frequency of the adoption of the adaptations (by practice type and by adaptation strategy). For the purposes of conducting the statistical tests, the null hypotheses are that there are no significant differences between the columns – i.e., that adaptation quality is not related to practice type or adaptation strategy.

With regard to practice type, there was no significant difference between the average adaptation quality index scores and frequency of adoption of the adaptations (P=0.73). However, the rarity of certain adaptations (and therefore the small n), such as education/outreach, policies, and floodplain management plans, may not provide enough power to analyze the data sufficiently.

Row Labels	Average of Additive Index	Count of Practice Type	P Value (T-Test)
Administrative	11.25	8	0.728706823
Capital Investment	9.166666667	6	
Education/Outreach	12.5	2	
Law - Building Code	12.04	25	
Law - Zoning Code	11.08695652	23	
Plan – Comprehensive	12.25	12	
Plan - Floodplain Management	12	1	
Plan - Hazard Mitigation	12.5	8	
Plan – Other	10	6	
Policy	12.66666667	3	
Study/Pilot Project	12.17391304	23	
Grand Total	11.64957265	117	

Table 4 - Average index ranking by practice type

With regard to adaptation strategy, again there was no significant difference between the average adaptation quality index scores and frequency of adoption of the adaptations (P=0.32). The quality ratings, therefore, do not appear to be related to frequency of adaptation adoption. This is not surprising, however, because many of these adaptations were experimental when adopted. Certain factors, such as costs, may have been known, but others, such as effectiveness and transferability, would not have been known in advance. Moreover, many adaptation projects were not initiated by the municipality or were a partnership, in which case the motivation to participate might not have come from expected outcomes. Cronbach's Alpha³⁶⁴ provides a measure of reliability between the measures of the index by determining the average correlation of the various index values. The Cronbach Alpha was calculated for the index charts with results as follows:

Strategy	Average of Additive Index	Count of Strategy	P Value (T-Test)
Accommodation	11.8	26	0.318389568
Prevention	10.6	21	
Procedural	12.1	62	
Protection	10.5	6	
Retreat	11.5	2	
Grand Total	11.6	117	

Table 5 - Average index rankings by IPCC strategy

³⁶⁴ Wessa P., 2012, Cronbach alpha (v1.0.2) in Free Statistics Software (v1.1.23-r7), Office for Research Development and Education, http://www.wessa.net/rwasp_cronbach.wasp/

Items	Cronbach Alpha	Std. Alpha	G6(smc)	Average R
All items	0.1816	0.2593	0.2197	0.0805
Costs excluded	0.2833	0.3046	0.2262	0.1274
Effectiveness excluded	0.1329	0.2141	0.1614	0.0832
Replicability excluded	0.1059	0.1937	0.1482	0.0741
Climate Chg excluded	0.0796	0.1037	0.0818	0.0371

Table 6 - Average index ranking with the Cronbach Alpha

The overall Alpha coefficient of .1816 indicates that the index has low internal consistency and that each of the variables are highly independent. This is an indication that there was low bias in responses to the questions and that each component measures independent characteristics.

CHAPTER 6-LEGAL IMPLICATIONS OF ADAPTATION STRATEGIES

6.1. IMPLEMENTING THE LAW OF ADAPTATION

While states have slowly begun to integrate adaptive thinking into their permitting and process laws dealing with coastal development, there are many outstanding legal issues that remain. One of the most significant challenges is the Fifth Amendment's takings clause, which states, "nor shall private property be taken for public use without just compensation."³⁶⁵ Policies which development densities, protect natural reduce areas. or prohibit redevelopment entirely could potentially violate landowner's constitutional rights. ³⁶⁶ Many adaptive projects and programs that were discussed in previous chapters may in fact be unconstitutional when applied. For instance, East Hampton's setback requirements could have the effect of prohibiting rebuilding or renovation of a substantially damaged home. In that case the landowner would most likely seek and be granted a variance from the board of appeals, but variances undermine the effectiveness of the law in enforcing a retreat from the shore. If the landowner were denied a variance and prohibited from rebuilding, they would likely have a good case to challenge the ordinance on constitutional grounds.

³⁶⁵ U.S. Const. Art. V.

³⁶⁶ Guercio, Lara D. "Climate Change Adaptation and Coastal Property Rights: A Massachusetts case study." *Boston College Environmental Affairs Law Review* 40 (2) (2013) 350-401, 306.

The reason that is the case is because the takings clause, which originally dealt only with physical expropriation, has been expanded by jurisprudence to cover regulations that "go too far" as to be equivalent to a taking.³⁶⁷ The U.S. Supreme Court explained its application to regulations in that the clause is intended to "bar government from forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole."³⁶⁸ This rule was a significant deviation from the general principle in English law that compensation is required only when government takes possession or acquires an interest in the parcel of land.³⁶⁹

To determine if a property owner is entitled to compensation, the Supreme Court uses a three-part balancing test first explained in *Penn Central Transportation Co. v. City of New York*, involving "the character of the governmental action, its economic impact, and its interference with reasonable investment backed expectations."³⁷⁰ *Penn Central* suggested that a regulation must deprive a landowner of all or almost all its value to effect a taking claim.

³⁶⁷As Justice Holmes famously said in Pennsylvania Coal Co. v. Mahon, 260 U.S. 393, 43 S.Ct. 158, 67 L.Ed. 322 (1922), "[g]overnment hardly could go on if to some extent values incident to property could not be diminished without paying for every such change in the general law." However, "if regulation goes too far it will be recognized as a taking." ³⁶⁸ 364 U.S. 40, 49 (1960)

³⁶⁹ D.R. Christie, 'A Tale of Three Takings: Takings Analysis in Land Use Regulation in the United States, Australia and Canada' (2007) 32 Brooklyn Journal of International Law 343-404.

³⁷⁰ 438 U.S. 104 (1978)

The law in the case was determined not to effect a taking, as it did not render Grand Central Terminal valueless, allowing its owner to earn a reasonable rate of return on investment. The court stated that the regulations did not interfere with the owner's "primary expectation concerning the use of the parcel."³⁷¹

The court, however, has subsequently created two distinct categories of government regulations it defined as a taking per-se, which obviate the need to engage in this balancing test. The first is when government causes a physical invasion of property, no matter how slight, and the second, which is more germane to the issue of coastal adaptation, is when a government regulation causes the complete devaluation of property.

In a case involving coastal regulations, *Lucas v. South Carolina Coastal Council*, ³⁷² the U.S. Supreme Court decided that the landowner was due compensation for a taking per-se, because South Carolina's Beachfront Management Act effectively prohibited construction, rendering the lots unbuildable and valueless.³⁷³ The court did say that if the regulation prevented a nuisance, that government would not have to pay compensation, but it was greatly limited in that regard. It could "no more than duplicate the result that could have been achieved in the courts - by adjacent landowners...under the

³⁷¹ Ibid. at 136.

³⁷² Lucas v. S.C. Coastal Council, 505 U.S. 1003 (1992)

³⁷³ Ibid. at 95.

State's law of private (or public) nuisance."³⁷⁴ This created a conundrum in which the state would now be limited to only traditional common law definitions of nuisance, despite the advances of science and the growing knowledge of the extent of harm that some types of land uses cause.

Subsequent rulings illustrate the pernicious effect this has had on the ability of governments to implement adaptation in floodplains, such as in *Mansoldo v. State of New Jersey*.³⁷⁵ In Mansoldo, the landowner brought an action for regulatory taking against the state claiming that a N.J. regulation prohibited construction of houses in a river floodway that was otherwise permitted by zoning.³⁷⁶ The law restricted him to use of the property only as parkland, open space, or a parking lot, constituting a regulatory taking. As explained by Freyfogle, "The court ruled, following the (U.S.) Supreme Court's lead, that Mansoldo deserved full payment for his land, including payment for its value if homes were built on it."³⁷⁷ Following Lucas, compensation would be required, regardless of the inherently hazardous use the landowner intended, unless the state could ban construction in a floodplain under background principles of nuisance law. Freyfogle explains that the court "could largely ignore the public

³⁷⁴ Ibid. at 192.

³⁷⁵ 187 N.J. 50, 58 (2006)

³⁷⁶ Ibid.

³⁷⁷ E.T. Freyfogle, On Private Property: Finding Common Ground on the Ownership of Land (Beacon Press, Boston, 2007), at p. 4.

policy reasons for the home - building ban...the state's policy reasons made no difference, nor did the public interest generally."³⁷⁸

Despite some state courts applying Lucas to the detriment of coastal adaptation, other state courts have been reluctant to find that floodplain regulations deny owners all value of their parcel. Courts "frequently find at least some economic value in land preserved as open space, for stormwater detention, as a viewshed amenity to adjacent property owners, or similar uses other than brick and mortar development."³⁷⁹ If courts find that regulations do not entirely deny owners all value of a property, the cases are analyzed under the *Penn Central* balancing test instead of the *Lucas* per se rule, giving them more flexibility to consider the burdens and benefits.

In an early case predating the *Lucas* decision, the Supreme Court of Massachusetts held that a total wipeout did not occur when the land could has natural remaining uses such as "woodland, grassland, wetland, agriculture, horticulture, or recreational use of land or water." ³⁸⁰ Some courts have continued to maintain this stance post-*Lucas*. The Maine Supreme Court, in a recent case regarding its coastal regulations, determined a taking had not

³⁷⁸ Ibid., 4.

³⁷⁹ E.A. Thomas, and S.R. Medlock, 'Mitigating misery: Land use and protection of property rights before the next big flood' (2008) 155 Vermont Journal of Environmental Law 157-188, at p. 187.

³⁸⁰ Turnpike Realty Company, Inc. v. Town of Dedham., 362 Mass. 221 (1972).

occurred when the only beneficial use of a property was for "parking, picnics, barbecues and other recreational uses..."381 The Court essentially ruled that even if the landowner could only sell the property as undevelopable adjacent space, it would not be a taking. Massachusetts' High Court ruled similarly when it denied a landowner's claim that a town's denial of a permit to construct a home in a coastal floodplain was a taking in Gove.³⁸² It denied the claim under Lucas, stating, "Gove has failed to prove that the challenged regulation left her property 'economically idle" since the property was worth \$23,000, "a value that itself suggests more than a 'token interest' in the property," as well as under Penn Central.³⁸³ The court determined that the landowner did not have property rights in a floodplain parcel where "potential flooding would adversely affect the surrounding areas if the property were developed with a house."³⁸⁴ The court said that government regulations "mitigating such harm, at the very least when it does not involve a 'total' regulatory taking or a physical invasion, typically does not require compensation."385

Despite some states' denial of compensation, the US Supreme Court continues to place limitations on coastal regulations. The Supreme Court further restricted the potential for governments to use managed retreat in *Palazzolo*

³⁸¹ Wyer v. Bd. of Environmental Protection, 747 A. 2d 192 (2000)

³⁸² 444 Mass. 754 (2005)

³⁸³ Ibid., 736.

³⁸⁴ Ibid., 767.

³⁸⁵ Ibid.

v. Rhode Island, ³⁸⁶ In which it held that notice of a regulation does not absolve the state from having to pay due compensation. Palazzolo ruled that a taking claim cannot be extinguished by prospectively prohibiting coastal redevelopment.³⁸⁷

In summary, U.S. Constitutional law suggests it will be very difficult for communities to avoid having to pay when they strictly regulate coastal development, and as a result, likely chills local governments from taking adaptive actions.

6.2. THE BUYOUT OPTION

For the vast majority of communities facing the threat of sea level rise, the option to pay compensation for relocation of endangered properties is not realistic. The options available to homeowners who are willing to leave, however, are few. The reality of dropping market value due to increasing flood insurance premiums and cognizance of risk can place homeowners in a bind – they can suddenly find the market value of their home below their mortgage, placing them in default and unable to find a buyer. Successful retreat programs do exist, however, especially in the case when federal funding is made available after a natural disaster.³⁸⁸ The plan proposed in New York State after Sandy

³⁸⁶ 533 U.S. 606 (2001)

³⁸⁷ Ibid. at 630-631

³⁸⁸ See e.g. Lisa Pittman, Plugs to Pull: Proposals for Facing High Great Lakes Water Levels, U.C.L.A. J. of Envtl. L. 213, 215 (1989) and Lisa A. St. Amand, Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration, 19 B.C. Envtl. Aff. L. Rev. 1 (1991)),

struck in October 2012 was especially ambitious. After the storm, New York Governor Cuomo announced that \$400 million of the \$51 billion the U.S. Congress approved in disaster relief funds in January 2013 would be spent to buy out up to 10,000 homeowners located in the 100-year floodplain.³⁸⁹ The plan originally provided for a bonus for homes in "highly-flood prone" areas as well as a doubling of the bonus for areas where an entire block agrees to sell to the state. Residents in the most vulnerable areas were to be able to sell to the state even if their home has not been damaged more than 50% by Sandy. In the undamaged areas, a 10% bonus was to apply if an entire block sold out. The state was supposed to turn these lots into dunes, wetlands, parks and other natural buffers.³⁹⁰

The plan was a managed retreat program without precedent in the United States, and suggested a substantial shift in the impulse to defend unsustainable settlement patterns. Initially, the state expected 10 to 15 percent of the 10,000 homes that were substantially damaged by Sandy to be sold to the state. The plan was predicated on economic compensation and incentives to sell that include offering pre-Sandy fair market value for homes as well as an array of bonuses, such as the offer to pay an additional ten percent

³⁸⁹ Thomas Kaplan, "Cuomo Seeking Home Buyouts in Flood Zones." *The New York Times*, Feb. 3, 2013.
³⁹⁰ Ibid.

to homeowners in a high risk area, and an additional ten percent in certain clusters if an entire block or neighborhood opted in.³⁹¹

These bonuses were quite innovative, but perhaps an even more notable shift in the history of disaster recovery was the significant grassroots support for the buyouts, which influenced the Governor's initial policy direction. Residents in the Staten Island neighborhood of Oakwood Beach, which was devastated by Sandy, organized a campaign to advocate for buyouts shortly after the storm hit. Joseph Tirone, Jr., a longtime neighborhood resident, led the Oakwood Beach Buyout Committee, drafted a petition and obtained signatures of neighborhood homeowners. Support was surprisingly not that difficult to obtain. The New York Times quoted Tirone as saying: "If you could wave a wand - a magic wand - and you said, everything's back to normal tomorrow, you'd still have close to 133 homeowners who want to leave because they just can't put up with it anymore."³⁹²

Another homeowner in the neighborhood, Joe Monte, had 10 feet of storm surge in his home, and expressed gratitude that Governor Cuomo bought out homeowners like him. In reference to potential criticism that the state might

³⁹¹ State of New York, "Action Plan for Community Development Block Grant Program Disaster Recovery,"." 25

³⁹² Colby Hamilton. "For Some Struggling on Staten Island, Buy-Outs Welcome." *WNYC.org*, February, 04, 2013. <u>http://www.wnyc.org/blogs/wnyc-news-blog/2013/feb/04/some-staten-island-buy-outs-welcome/</u> (Retrieved on 8 April 2015)

be overpaying for the battered homes, he said, "This is no lottery ticket...I'm losing money and I really don't care, because my wife is alive and my children are alive."³⁹³

It is clear, however, that such a shift is far from universally accepted. As one Long Beach, New York resident said, "We live here, this is where our homes are, where our children were raised, and the businesses that we go to are...the Governor should be looking at ways to help people stay in their communities..."³⁹⁴ Another resident who posted a response to the Governor's plan had this to say: "You know, I've never heard anyone tell the people on the Outer Banks or the coast of Florida or maybe NEW ORLEANS to move! These storms happen there all the time! Go to hell."³⁹⁵

However wise an investment to reduce future costs of damage, it was only made possible by the enormous federal funding available because of Sandy. The program also has some severe limits. Most expensive homes are excluded and payments are capped at the median value of a neighborhood.³⁹⁶ In addition, surely not every community in every region of the country at risk from climate change will be made such an offer.

³⁹³ Ibid.

 ³⁹⁴ Quijano, Elaine. "Sandy Storm Victims React to Proposed Home Buyout." CBSNews.com,
 5 February 2013. http://www.cbsnews.com/news/sandy-storm-victims-react-to-proposed-home-buyout/ (retrieved on 8 April 2015)

 ³⁹⁵ Goodyear, Sarah. "Tough Talk from Cuomo: 'Maybe Mother Nature Doesn't Want You Here'." *The Atlantic Cities*. Jun 25, 2013.
 ³⁹⁶ Ibid.

The plan to buy out vulnerable homes is being questioned by many who wonder why government must use taxpayer funds to pay more than market value to compensate those that made the dubious decisions build in harm's way. The decision to use public money to buy out homeowners is, no doubt, because it might be the only politically acceptable means to retreat from the most dangerous flood zones. But it is also predicated on the law - that is, the presumption that to prohibit redevelopment through regulatory means would be an unconstitutional taking of property, in contravention of the Fifth Amendment. If government is prohibited by the Constitution, or by politics, from prohibiting rebuilding after a storm, then it must consider alternative strategies to pay compensation that do not rely on massive buyout programs which put the federal government's solvency at risk. Many of the tools researched in this dissertation are promising alternatives to buyouts. One such tool which had particular promise and has proven to work in coastal retreat scenarios is Transfer of Development Rights (TDR).

6.3. TRANSFER OF DEVELOPMENT RIGHTS AS AN ADAPTATION OPTION

Because buyouts are prohibitively expensive and legal options are limited by takings, we must look at other alternatives to manage coastal adaptation. One such option is TDR, which was utilized perhaps most successfully in Ocean City, Maryland.



Figure 28 - - Ocean' City's dunes facilitated by TDR

TDR is a sophisticated system of land use regulation intended to balance the injustice of losses and gains due to land use regulation. TDR has been called "the most innovative, imaginative and potentially effective technique of land use control...since the introduction of zoning and subdivision regulations."³⁹⁷ TDR has been used to protect farmland from development, to prevent development in floodplains, and to protect historic sites in cities. Yet, TDR has only found modest success in a few states, because of a number of common weaknesses. It has found most success in preserving farmland and open space in exurbia. Yet, there is a large untapped potential for TDR to have a role in coastal resilience and sea level rise adaptation, though its use in coastal areas presents some unique challenges and opportunities. The high value of coastal property and a lack of areas suitable for receiving zones pose challenges.

³⁹⁷ Jerome G. Rose, "Psychological, Legal and Administrative Problems to the Proposal to Use the Transfer of Development Rights as a Technique to Preserve Open Space,"." 6 Urb. Law 919 (1974)

However, there are features of coastal areas that make them more suitable to the effective use of TDR.

The concept of transferring development rights in the coastal zone is not new. In 1978, Ascher argued that such a scheme could be a viable alternative to wetlands regulation.³⁹⁸ He suggested TDR could more efficiently preserve coastal wetlands than purchase alone. He wrote, "[P]erhaps the most persuasive argument for transfer of development rights is that the implementation of such a program puts no strain on the government fisc because the development rights would be purchased by private property owners."³⁹⁹

Equally, if not more important, is the argument that TDR is more fair to landowners than regulation without compensation. TDR, furthermore, may make coastal protection programs politically feasible. Costonis, in a seminal article, argues that TDR "promises resource protection without calling for drastic inroads settled constitutional principles or for public programs that are politically unfeasible."⁴⁰⁰

³⁹⁸ Ascher, David M. The Acquisition of Development Rights in the Coastal Zone: An Alternative to Wetlands Regulations. Sea Grant L. & Pol'y J. 2 (1978): 95.
³⁹⁹ Ibid., 140.

⁴⁰⁰ John J. Costonis, Development Rights Transfer: An Exploratory Essay, 83 Yale L.J. 75 (1973), 96.

TDR programs are designed to shift development from "sending" areas, where the community wants to preserve land, to locations more appropriate for development, called "receiving" areas. In the context of coastal communities, immediate shorelines, wetlands, dunes and bluffs should be considered sending areas, and inland locations, preferably not in floodplains, should be receiving areas.

TDRs have been authorized by statute in over 20 states and all ten states in the North Atlantic region, and they have been used to a successful degree in various settings. Implementation of TDR is complex however, and despite the successes, many programs are set up that do not actually result in significant numbers of transfers. A study of 111 TDR programs found that 46 of them had preserved fewer than 5 acres.⁴⁰¹ Ten, however, preserved over 1000 acres of sensitive land.⁴⁰² Challenges include potential legal problems with the takings clause, geographical and jurisdictional challenges that make it difficult to find the locations appropriate for sending and receiving areas, and administrative challenges can also impact the ability of local governments to implement effective TDR programs. Despite these challenges, a number of communities have been successful at implementing TDR in the coastal zone, and they can serve as examples of how to effectively implement a program.

⁴⁰¹ Bruening, Ari D. "."The TDR Siren Song: The problems with transfer of development rights programs and how to fix them." 23 *J. Land Use & Envtl L.* 23 (2007): 424 (citing another source) ⁴⁰² Ibid.

New York City first implemented a TDR system in 1968 to complement its Landmarks Preservation Law.⁴⁰³ It is arguably the most successful such program in the country. The program famously preserved Grand Central Terminal and was the subject of the landmark Penn Central case, and continues to have a significant influence on the built environment.⁴⁰⁴ Our study illuminated a number of successful TDR programs that have helped achieve coastal adaptation, in particular in Maryland and New Jersey, which are the two states recognized as having the most successful TDR implementation.⁴⁰⁵

6.3.1. Maryland

Maryland's TDR program dates from 1985 and is one of the most extensively adopted in the country. ⁴⁰⁶ The state has had the most success preserving farmland in two fast-growing, exurban counties -- Montgomery and Calvert. As of 2007, Maryland has preserved 68,000 acres of open space, mostly in the

⁴⁰³ Landis, Marc A., Kevin B. McGrath, and L. Smith Lonica. "Transferring Development Rights in New York City." *New York Law Journal*, Real Estate Trends. (2008).

⁴⁰⁴ See e.g. Been, Vicki and John Infranca, "Transferable Development Rights Programs, 'Post Zoning'?" 78 *Brooklyn L. R.* (2012): 435. The authors suggest that TDR played a critical role in the preservation of the High Line in Chelsea, one of the most celebrated urban public spaces in recent history.

⁴⁰⁵ Pruetz, Rick and Erica Pruetz, "Transfer of Development Rights Turns 40." 59 Plan. & Envtl. L. (2007): 3, 3

⁴⁰⁶ Md. Code. Ann., Art. 66B, § 11.01 (2005)

form of farmland.⁴⁰⁷ Maryland is also home to the most significant TDR program to have effected coastal retreat. Ocean City, Maryland's only oceanfront municipality, has one of the most unique and successful TDR programs in a U.S. coastal community.

Ocean City has a census 2010 reported population of 7,102, but its summertime population is estimated between 320,000 and 340,000 on peak weekends.⁴⁰⁸ Ocean City's first lots were surveyed in the 1860's and a 400-room hotel opened in 1875, and a railroad was completed in 1878 across the Sinepuxent Bay, which separates it from the mainland Delmarva.⁴⁰⁹ Ever since then, the town has welcomed visitors, many of whom own condos and timeshares, largely from the Baltimore, Wilmington, and Philadelphia metropolitan regions. Over 8,000,000 tourists visit Ocean City annually, which generates nearly \$3 billion in revenue.⁴¹⁰ A major boom in development occurred throughout the 1970s and 1980s, creating the significant high rise skyline that characterizes the city today.

 ⁴⁰⁷ Dehart, Grant H. and Rob Etgen, "The Feasibility of Successful TDR Programs for Maryland's Eastern Shore." Eastern Shore Land Conservancy (2007). http://www.eslc.org/wpcontent/uploads/2013/12/Transfer-of-Development-Rights.pdf
 ⁴⁰⁸ Ocean City, MD. "Draft Multi Hazard Mitigation Plan." (2011), 20. http://oceancitymd.gov/Planning_and_Zoning/hazard-mitigation-plan.pdf
 ⁴⁰⁹ Ibid.

⁴¹⁰ Ibid.

Ocean City is no stranger to storms and the risk from building on the coast. Its Hazard Mitigation Plan focuses on coastal and tropical storms as the most cognizant threat, and states "nearly any part of town is equally vulnerable...oceanfront structures will endure high wind and waves...bayfront structures will see flooding and debris damage..."⁴¹¹ The entire land area of Ocean City is in the FEMA-designated flood zone and is very subject to damage from hurricanes - a category 1 hurricane would inundate 69% of the city, category 2 storm would inundate 79% and a category 3 or higher would inundate 100% of the city.⁴¹² Luckily, in 127 years of record keeping, Ocean City has never experienced a direct landfall of a hurricane, although some have brushed the city.⁴¹³

Ocean City's Transfer of Development Rights program began as a desire to protect the city through beach replenishment.⁴¹⁴ But before the TDR program was conceived, the town set in motion the regulatory scheme to make it possible.⁴¹⁵ The town established a build-to-line, which was strictly enforced, in the early 1970s. The line was established generally at the historic extent of eastward development. This created some nonconforming buildings, mostly beach clubs and other seasonal structures, and many lots became

⁴¹¹ Ibid.

⁴¹² Ibid., 35.

⁴¹³ Ibid., 37.

 $^{^{414}}$ In person interview with Blaine Smith, Ocean City, Md. Town Planner (Aug. 23, 2012) 415 Ibid.

unbuildable.⁴¹⁶ The line was maintained fixed in perpetuity, regardless of how much sand was pumped and how wide the beach became due to replenishment. Town Planner Blaine Smith explained that there was intent to acquire the nonbuildable properties at the time the town established the line, but the city did not have the funding to proceed with condemnation actions.⁴¹⁷

What pushed the town to acquire the lots came about approximately twenty years later. In the early 1990s, The Army Corps of Engineers, The State of Maryland, Worcester County, and Ocean City partnered to design and fund a \$45,000,000 coastal infrastructure project, called the Atlantic Coast of Maryland Shoreline Protection Project. It consisted of the construction of a 220 foot-wide dry sand beach, a steel sheet pile seawall in front of the town's boardwalk, and the construction and planting of an artificial dune, 25 feet wide at its crest and 85 feet wide at its base, which was subsequently planted with 65 acres of beach grasses.⁴¹⁸

The Army Corps required the town to control, either through fee acquisition or easements, all of the land east of the building limit line as a precondition to the receipt of funds for the Shoreline Protection Program.⁴¹⁹ The town, facing

⁴¹⁶ Ibid.

⁴¹⁷ Ibid.

⁴¹⁸ Ibid.

⁴¹⁹ Ibid.

enormous potential bills to compensate landowners for the acquisition, created the TDR program to compensate owners for private property taken to construct the dunes in areas north of the city's boardwalk and seawall.⁴²⁰

Like most TDR programs, it created both sending and receiving areas. This process creates many of the political troubles and is often the downfall of TDR programs. An overlay receiving district was established in the highest density zones, generally located in the blocks behind the dunes, and created a 25% density bonus for any project that used TDRs, to encourage a market for the credits. One development right was awarded for every 500 square feet of land area in the sending district.⁴²¹ The program was an unqualified success. It was extensively used by property owners and over 400 rights were transferred since the program was established. About 70 rights remained to be used as of 2012. The value of the development rights have varied with the market, proving that the credits truly represented value. Some property owners received up to \$2.5 million for their credits.⁴²²

Although many municipalities fear the complexity of a TDR system, Ocean City proves that it doesn't have to be. As their town planner explained, "We tried to keep it as simple as we could...we just issued piece of paper that we

⁴²⁰ Ibid.

⁴²¹ Ibid.

⁴²² Ibid.

made on our computer...we don't get involved with the money and transactions...it gets assigned with the deed."⁴²³ TDR programs often have implementation challenges when the value of the credits is uncertain or if the market is weak. That was not a problem in Ocean City, and indeed, in most coastal areas, since property values tend to be high.

Ocean City established a TDR program to enforce a coastal retreat strategy. It also managed to implement a mandatory TDR program without any landowners bringing a takings suit. Although Ocean City landowners might not be the litigating type, a better explanation is likely that the TDRs were seen as adequate and just compensation. This is an interesting outcome given the Supreme Court's recent precedents which cast doubt on the validity of TDRs to provide compensation for a taking. Ocean City is not alone in its success, and a number of other coastal communities in Maryland also have active TDR programs, including Queen Anne's County, St. Mary's County, Talbot County, Wicomico County, Charles County and Cecil County.

6.3.2. New Jersey

New Jersey first passed legislation permitting towns to establish TDR programs for use in its special planning areas - first in the Pinelands in 1981, and later in the Meadowlands. In 2004 the state subsequently enacted the N.J.

⁴²³ Ibid.

Transfer of Development Rights Act which authorized all municipalities in the state to use TDRs.⁴²⁴

New Jersey's TDR program is often considered the most advanced and extensive in the country. One of the reasons for that success was the establishment of a TDR bank by the state, funded by a bond. Another bond act for infrastructure improvements in receiving areas was passed to encourage the success of the program after a slow start.

TDR programs supports the municipality's land use designations and master plan that are coordinated with the state plan. Ocean and Berkeley Townships are the two towns in the Jersey Shore region that have been actively engaged with establishing a TDR plan. Ocean Township was one of the first communities on the Jersey Shore to apply for a TDR program. The town wanted "to use TDR to preserve its unique environmental and coastal resources, and direct new development to a designated Center (the Waretown Town Center)."⁴²⁵

⁴²⁴ N.J. Stat. Ann. §§ 40:55D-137 to 40:55D-163 (2005)

⁴²⁵ N.J. State Transfer of Development Rights Bank Board, "Summary of State Transfer of Development Rights Bank Activities" 2006.

The TDR program supports the municipality's land use designations and master plan that are coordinated with the state plan. The purpose of the state plan is to:

...coordinate planning activities and establish statewide planning objectives in...land use, housing, economic development, transportation, natural resource conservation, recreation, urban and suburban redevelopment, historic preservation, public facilities and services, and intergovernmental coordination.⁴²⁶

The plan categorizes all land in the state into "areas for growth," "areas for limited growth" and "areas for conservation." Special areas are designated for the N.J. coastal zone. Ocean Township was the second town in the state to complete the Plan Endorsement process, the system by which a town achieves consistency and gains approval of its master plan by the state planning agency.⁴²⁷ A number of benefits accrue to a municipality that voluntarily submits to the Plan Endorsement process. The benefits include higher priority for state funding, streamlined permit reviews, coordinated state agency service, approval or renewal of coastal center designations, and the ability to change center designations and/or state planning areas.

While voluntary, New Jersey law requires plan endorsement as a precursor for state approval of centers in New Jersey's coastal region. While there are

⁴²⁶ N.J.S.A. 52:18A-200(f)

⁴²⁷ See N.J. State Planning, "Cross Acceptance." <u>http://www.nj.gov/state/planning/plan-cross-acceptance.html</u> "Cross-acceptance is a bottom-up approach to planning, designed to encourage consistency between municipal, county, regional, and state plans to create a meaningful, up-to-date and viable State Plan." (N.J.S.A. 52:18A-202.b.).

benefits to designating areas in a town a center anywhere in the state, the stakes are significantly higher in the area regulated by Coastal Area Facilities Review Act (CAFRA). This is because, under state rules, the amount of impervious coverage permitted in the CAFRA zone is limited.⁴²⁸ The 1993 amendments to CAFRA required rules to be adopted that required CAFRA zones to be coordinated with the State Plan.⁴²⁹ The new rules set limits for impervious and vegetative coverage based on the designation of a parcel's location in a CAFRA zone - a center, core, node, Coastal Planning Area or Coastal Center. The highest densities and coverages were allowed in the coastal or CAFRA Centers. If a town wanted to permit development, it often had to have its impervious coverage limits increased by applying the NJDEP to change the designated CAFRA zone, which thus required that the town complete the process of Plan Endorsement.

The Township is also preparing a vision plan and form-based code for its center plan, which includes design guidelines and a transportation development district. This type of integrated planning represents perhaps one of the best examples of coordinated state and local climate mitigation and adaptation planning. The program did not take off, but calls for more and better planning since Sandy hit the state have generally failed to take account of the sophisticated program already in place.

⁴²⁸ N.J.A.C. 7:7E-5B.4

⁴²⁹ N.J.S.A 13:19-1 et seq.

6.3.3. TDR in Other States in the North Atlantic

Maine authorizes TDR,⁴³⁰ but has not had widespread success. Two towns -Brunswick and Cape Elizabeth - attempted to establish TDR programs but were considered fairly unsuccessful. The Town of York recently instituted a transfer of development rights program to discourage development in coastal wetlands in York Beach.⁴³¹ The program was instituted after homeowners brought regulatory takings cases against the town, and the courts accepted the use of TDR as just compensation. Owners of wetland property can now transfer the development rights to an area outside the wetlands. There is no credit bank, so the program only works if a seller can find a willing buyer. Unfortunately, the town has not seen any TDR transactions yet. The program doesn't allow building in a wetland, but it allows landowners to recoup some of the loss of value from the development prohibitions.

TDR was authorized by statute in New Hampshire in 2004. ⁴³² New Hampshire's law permits local governments authority to require "innovative" land use controls if they are supported by the master plan and defines TDR as an "innovative" land use control.

⁴³⁰ Title 30-A Chapter 187 § 4328

⁴³¹ Town of York, ME, Ordinance §7.6.4.B.3

⁴³² N.H. Rev. Stat. Ann. § 674:21 (2004)

Massachusetts authorized TDR in 2005.⁴³³ Many towns to experiment with TDR are inland exurban communities seeking to protect open space and farmland in high-growth parts of the state. Two towns on Cape Cod have attempted to implement at TDR program - Falmouth and Mashpee. The Falmouth TDR is a town-wide program. Other Massachusetts towns that have town-wide programs are non-coastal Plymouth and Groton. Mashpee had attempted to set up an innovative program using a formula weighted for desirability of land protection, but requires that transfers occur only within an Open Space Incentive Development.

Rhode Island also authorizes TDR in R.I. Gen. Laws § 45-24-33(b)(2)(2004), but only has two programs currently in force in the state – in North Kingstown and Exeter⁴³⁴. Rhode Island is currently working on improving its program. In Connecticut, TDR is permitted by State Statute Ch. 24 §§7-2f and 8-2e to 8-2f. Connecticut also allows inter-municipal TDR, which permits sending and receiving districts across town lines. However, TDR has not been widely used in Connecticut.

New York was one of the pioneering states to establish TDR.⁴³⁵ One of the oldest and most successful programs in the country is the Pine Barrens TDR

⁴³³ Mass. Gen. Laws. Ch. 40A, § 9 (2005)

⁴³⁴ Nathan Kelley. Rhode Island Transfer of Development Rights Manual. (Feb. 2015) http://www.dem.ri.gov/programs/bpoladm/suswshed/pdfs/devright.pdf ⁴³⁵ N.Y. Tarme Lem S201 a. Village Lem S7, 701 and Canada City Lem S20

 $^{^{435}}$ N.Y. Town Law §261-a, Village Law §7-701 and General City Law §20.

on Long Island. A partnership between Suffolk County, New York State and the towns of Southampton, Brookhaven and Riverhead, the program was established in 1995 to protect a 10,000 acre are of Pinelands that is an important source of drinking water and endangered species. Riverhead extended its program to protect farmland in the town, but has not used the program to protect shoreline coastal areas. Coastal communities which have a TDR program include Southold, Southampton, Riverhead, and East Hampton, all on the east end of Long Island.

Section 310 of the Delaware Code permits towns to use TDR, but the program is very minimal and simply permissive.⁴³⁶ Separate legislation permitted Kent County and New Castle County to establish TDR programs but they have also struggled with implementation and effectiveness.

Virginia authorized TDR in 2006, although its program is somewhat limited.⁴³⁷ A municipality in Virginia must amend its comprehensive plan to show its TDR sending and receiving areas as well as to establish procedures, methods and standards for TDR. In Virginia, landowners must proceed "arm-in-arm" to the courthouse to make an agreement between sending and receiving landowners. This is a significant limitation that programs like New Jersey's TDR bank have attempted to overcome.

⁴³⁶ Del. Code § 310, Del. Code Title 9 §4953

⁴³⁷ Va. Code § 15.2-2316.1 et. seq. (2006)

6.4. TDR AND TAKINGS

No constitutional issues would seem to be of concern in the case of a voluntary sale program, such as the program proposed in New York. If government offered or supplemented the purchase price with TDRs, any landowner would be free to accept or reject the offer as a voluntary transaction. However, a program that prohibited redevelopment of flood-damaged homes that offered TDRs as compensation would likely run afoul of the prohibition of the Fifth Amendment of the Constitution, which states: "nor shall private property be taken for public use without just compensation."⁴³⁸

Technically it seems feasible for a local government to restrict reconstruction of a property damaged in a coastal storm. As Randall explains, "conceptually, this could be accomplished by framing the regulation as a valid exercise of the state's police power to protect the safety, health, and welfare of the public."⁴³⁹ However, the Supreme Court's decisions cast a pall on the ability of government to protect its citizens by disallowing them to put themselves in harm's way. TDR has been bound up in the takings debate since the Supreme Court upheld the New York City Landmarks Preservation Law in Penn Central Transportation Co. v. New York City.⁴⁴⁰ The landmarks law used TDRs to allow the transfer of the rights above Grand Central Terminal to

⁴³⁸ U.S. Const. Art. V.

 ⁴³⁹ Randall, Martin. "Coastal Development Run Amok," *18 J. Envtl. L. & Litig.* 171 (2003)
 ⁴⁴⁰ 438 U.S. 104 (1978)

buildings they owned in the vicinity. Penn Central both gave us the test to determine whether a regulation is a taking and dealt with the role of TDRs in a takings context. Penn Central suggested that a regulation must deprive a landowner of all or almost all their value to effect a taking claim. The majority decision did not ascertain whether TDRs could abrogate a takings claim by allowing a landowner to retain some of his rights to the property, but, in dicta, Justice Brennan explained the role that TDRs do have in compensating landowners for regulatory burdens:

[While] these [TDRs] may well not have constituted "just compensation" if a "taking" had occurred, the rights nevertheless undoubtedly mitigate whatever financial burdens the law has imposed on appellants and, for that reason, are to be taken into account when considering the impact of the regulation.⁴⁴¹

New York City's landmarks preservation law was not upheld on the grounds that the TDRs provided "just compensation" for the taking. The landmarks law did not render Grand Central Terminal valueless. Rather, it continues to operate to this day as a train station, with numerous concessions and office space, allowing its owner to earn a reasonable rate of return on their investment. The court stated that the regulations did not interfere with the owners "primary expectation concerning the use of the parcel."⁴⁴² In Penn Central, the value of the TDRs were not an issue, because the court did not find the landmark preservation law to be a taking. Nevertheless, the court gave

⁴⁴¹ See Ibid. at 137.

⁴⁴² Ibid. at 136.
a nod to their significance that would suggest support for including them in valuation calculations under the economic impact prong of the three-part test. A local law which prohibits redevelopment and offers TDR as compensation would also have to be considered in light of the Supreme Court's decision in Lucas v. South Carolina Coastal Council.⁴⁴³ However, a government is only liable for a taking under Lucas if the landowner is deprived of all reasonable value, value that could be retained in the form of TDR credits. Regulations which would mitigate the impact of development in floodplains could reasonably be expected to deprive landowners of all uses of a parcel, but any such law would be subject to the three-part test to determine whether a taking had occurred.

If the court decides that such a program would indeed be a taking, then the TDRs could potentially be used as compensation. The Supreme Court considered this issue in case of *Suitum v. Tahoe Regional Planning Agency.*⁴⁴⁴ The plaintiff in the case argued that the Court should find a taking under Lucas, since the land had been rendered valueless by the regulation. Mrs. Suitum owned a parcel of land within the Tahoe Regional Planning Agency's jurisdiction and subject to its strict development regulations designed to protect the clarity of the water in Lake Tahoe. In Suitum, the government prohibited any permanent disturbance of the soil on plaintiff's parcel, and gave

⁴⁴³ Lucas v. S.C. Coastal Council, 505 U.S. 1003 (1992)

⁴⁴⁴ Suitum v. Tahoe Regional Planning Agency, 520 U.S. 725 (1997)

her TDRs that were of dubious value. The Suitum court ruled that when a regulation rendered property useless, TDRs could only serve to compensate a landowner, not absolve liability for a categorical taking under Lucas. Thus, the Supreme Court's takings jurisprudence leaves TDR programs which serve to support coastal retreat vulnerable to attack, first turning on whether the law would be seen as a taking at all under Lucas, and further analysis regarding whether the TDRs offered have discernible value.

In light of Suitum, local governments might be wary of implementing coastal programs involving TDR. Commentators have suggested that "the Suitum decision may spell the beginning of the end for TDRs as a protection against takings challenges."⁴⁴⁵ But one significant difference is the extent of the harm government is seeking to prevent. In Suitum, it was water quality that was at issue - in the case of areas damaged in a storm, an inherently hazardous use, does government have to allow a homeowner to rebuild at all?

The need for TDR is predicated on the theory that government would not, or could not, prohibit reconstruction of structures in a coastal flood zone without paying just compensation. Most articles on the subject of sea level rise and climate change analyze the potential of the public trust doctrine and rolling easements to obviate the necessity for government to pay for takings of private

⁴⁴⁵ Lazarus, Richard. Litigating Suitum v. Tahoe Regional Planning Agency in the United States Supreme Court, 12 J. Land Use & Envt'l. L. 179 (1997)

property as the sea subsumes former dry land. The reality, however, is that sea level rise is unlikely to manifest in gradual inundation, but rather through increasingly frequent and destructive storms. The common law doctrine of avulsion, however, typically does not recognize changing property boundaries caused by a rapid unpredictable event.

The Fifth Circuit's decision in Severance v. Patterson bolstered this limitation when it held that a rolling easement established by the Texas Open Beaches Act did not "roll" inland after a hurricane caused avulsion. ⁴⁴⁶ Williams explains:

A further disadvantage of rolling easements is that they do not generally prevent development in areas vulnerable to crippling inundation from hurricanes like Sandy or Katrina, as the easements generally provide that structures must be removed only once the mean high tide line advances to a certain point.⁴⁴⁷

However, another theory might be employed to recognize the right of government to prohibit rebuilding after a storm substantially destroys a coastal structure - that is the right of government to enjoin a nonconforming use through amortization. If no compensation is due because of legal amortization, the value of TDRs would in that case not be as compensation for a taking, but as political currency to ensure support for the program and financial support for those enduring the hardship of destroyed property.

^{446 566} F.3d 490 (5th Cir. 2009)

⁴⁴⁷ Williams, Nicholas R. "Coastal TDRs and Takings in a Changing Climate." *The Urban Lawyer* 46.1 (2014): 139-72.

The Supreme Court recognized the right of government to terminate a nonconforming harmful use before the first comprehensive zoning ordinance was passed, ⁴⁴⁸ and ten years before zoning was declared constitutional in Euclid v. Ambler.⁴⁴⁹ In 1915, the court decided that the City of Los Angeles could enjoin the nonconforming operation of a brick manufacturing business in Hadacheck v. Sebastian.⁴⁵⁰ The City of Los Angeles passed an ordinance prohibiting the operation if a brickyard or brick kiln within a certain zone of the city. The brickyard owner, Mr. Hadacheck, had established a brickyard on his property legally, in an area outside the city limits. Hadacheck's land was subsequently annexed to the city, and zoned into a district in which brick making was prohibited. In the early and prescient case, the landowner claimed the ordinance effected an unconstitutional taking and violated the U.S. and California Constitutions.

He argued that his land was acquired specifically for the manufacture of bricks, since it held valuable deposits of clay good for that express purpose. He also attempted to dispel the notion that his use could be considered a nuisance, claiming that he emitted no noise or noxious odors, that he created as little smoke as possible, and that no complaints had been made in the seven years

⁴⁴⁸ The first comprehensive zoning ordinance is recognized as having been passed into law by the City of New York in 1916.

⁴⁴⁹ Village of Euclid v. Ambler Realty Co., 272 U.S. 365 (1926)

⁴⁵⁰ Hadacheck v. Sebastian, 239 U.S. 394 (1915)

he had been in business. The city argued that the district had become primarily residential and that residents were suffering due to his activities.

Hadacheck argued that the land was worth \$100,000 per acre for brick making, but only \$60,000 for residential or other purposes. He further claimed that investments he made for the manufacture of bricks, including the construction of kilns, machinery and buildings, made it costly or impossible to put it to any other use. He claimed he would have to abandon the operation and business and therefore would be deprived of his property. The Supreme Court held that the ordinance was a legitimate use of the police power and that no taking had occurred. The rule in Hadacheck is sometimes called the "nuisance exception" to the takings clause. Klein explained that "In theory, traditional takings law has long recognized a nuisance exception under which landowners are not entitled to compensation when they are precluded from using their land to create a nuisance."⁴⁵¹

One clear difference between Hadacheck and the hypothetical amortization of structures in coastal flood zones is that Hadacheck was not deprived of the entire use of his property. He was free to sell it or use it for residential uses. Amortization most often is applied to the discontinuation of a particular use in a zoning code, and not the entire use of a property. However, even in the case

⁴⁵¹ Klein, Christine A. "The New Nuisance: An Antidote to Wetland Loss, Sprawl, and Global Warming," 48 *B.C. L. Rev.* 1155, 1195 (2007).

where all uses are prohibited, a taking claim might fail since amortization implies landowners are permitted a reasonable time period to recoup their investment.

The reasonable time rule is in fact a critical component to state court decisions permitting amortization. The state courts of New York, Maryland, Indiana and Mississippi have generally followed the common-law rule that a nonconforming use can be terminated as long as an owner is permitted a reasonable time to obtain a return on his or her investment.⁴⁵² However, other state courts have held that amortization cannot avoid a taking without paying just compensation. Illinois and Pennsylvania courts support this view.⁴⁵³

In these cases, for the most part, courts have permitted amortization when the use is harmful or dangerous. Clearly, development in the coastal floodplain comes as close to "harm" to one self and the public fisc as one could contemplate in the context of land use. The Supreme Court has said so much, in First English Evangelical Lutheran Church of Glendale v. County of Los Angeles: "If there is a hierarchy of interests the police power serves--then the

⁴⁵² Modjeska Sign Studios, Inc. v. Berle, 373 N.E.2d 255, 262 (N.Y. 1977); Trip Assocs. v. Mayor and City Council of Baltimore, 898 A.2d 449, 457 (Md. 2006); Bd. of Zoning Appeals v. Leisz, 702 N.E.2d 1026, 1032 (Ind. 1998); Red Roof Inns, Inc. v. City of Ridgeland, 797 So. 2d 898, 902 (Miss. 2001); See Also Osborne M. Reynolds, Jr., "The Reasonableness of Amortization Periods for Nonconforming Uses— Balancing the Private Interest and the Public Welfare," 34 Wash U. J. Urb. & Contemp. L. 99, 109 (1988).
⁴⁵³ City of Oakbrook Terrace v. Suburban Bank & Trust Co., 845 N.E.2d 1000, 1011 (Ill. App. Ct. 2006); PA Nw. Distribs., Inc. v. Zoning Hearing Bd., 584 A.2d 1372, 1376 (Pa. 1991)

²⁰⁷

preservation of life must rank at the top. Zoning restrictions seldom serve public interests so far up on the scale..."⁴⁵⁴ The court explained that land use regulations of lesser import are often outweighed by constitutional property rights. But in this case, concerning development in a floodplain:

The zoning regulation...involves this highest of public interests...[Ilts avowed purpose is to prevent the loss of lives in future floods...We need not address the ultimate question - is the public interest at stake in this case so paramount that it would justify a law which prohibited any future occupancy or use of appellant's land.⁴⁵⁵

Poirier suggested such a rule might provide sufficient amortization and respond to the prong of the Penn Central test that requires the government to consider a property owner's prior expectation.⁴⁵⁶ Courts have given some support to this argument.⁴⁵⁷ The counter argument is that throughout U.S. history, the expectation has been that one could rebuild after a storm, and shifting expectations as owners change would seem not to be permissible under Pallazollo.

Poirier suggests there is political value in the uncertainty of prohibitions on rebuilding tied to substantial loss in a storm, since it is not dictated by people. Many local codes already use this standard to require compliance with new,

^{454 482} U.S. 304

⁴⁵⁵ Ibid.

⁴⁵⁶ Marc R. Poirier "Takings and Natural Hazards Policy: Public Choice on the Beachfront." *Rutgers L. Rev.* 46 (1993): 243.

⁴⁵⁷ The statute in Lucas also had a rebuilding prohibition, and that portion of the statute was upheld against a facial challenge *in Esposito v. South Carolina Coastal Council.*

more stringent regulations. However, amortization is required to be reasonable, and a storm- timeline might not be considered long enough if one occurs too soon. A more constitutionally sound solution might be for a municipality to establish a fixed time period, tied to science-based predictions of flood zone inundation, beyond which a land use could be terminated.

One of the problems in Lucas was that the hazard the government was preventing was speculative, and all other similarly situated owners were permitted to build. A prohibition on rebuilding after a storm would apply to all homeowners similarly situated, creating a presumption of fairness. When government allows the continuation of the use until Mother Nature proves, beyond a reasonable doubt, that the use is harmful, there should be no constitutional taking.

6.5. TDR AS A SOLUTION?

Although TDR and amortization provide solutions to coastal adaptation, there are remaining legal uncertainties. TDR has a record of challenges with implementation, and it is most successful in places where there is a strong market demand for development. Most of the northeast coast fits this description, though there are exceptions where communities struggle to attract investment. TDR has primarily been used for preserving farmland in fast growing suburbs and exurbs, and there are comparatively few coastal examples. There are likely a number of reasons for this, primarily because of the high value of coastal property and a lack of areas suitable for receiving zones. Allowing transfer of TDR credits across municipalities or counties could alleviate some of these problems, but doing so increases the complexity of the program. New TDR programs like Virginia's are very limited and therefore have not found much implementation. States such as New Jersey and Maryland have had the most success at implementing TDR because of their advanced programs such as the N.J. TDR bank. There is also a steep learning curve and administrative costs are high for local governments not accustomed to the program. Nevertheless, because there is so much to be gained, application of TDR programs should be explored in more depth and detail for use in coastal adaptation.

6.6. CONCLUSIONS

A significant number of historic and current federal, state and local programs have added up to a meaningful effort to adapt to climate change on the U.S. coast. As stated by Blakely and Carbonell, "coastal cities and states in the United States...are stepping forward, in many cases well ahead of other developed nations and the international community, both to mitigate and adapt to climate change."⁴⁵⁸

Although subject to criticism, historic coastal zone programs such as the Coastal Zone Management Act and FEMA's programs such as the HMGP and

⁴⁵⁸ Carbonell and Blakely, 264.

CRS have contributed significantly to adaptation. More recently, the federal government and the Obama administration have taken some steps to begin to incorporate adaptation and resilience thinking into its rules, although much more could be done.

Much more action is being taken at the state and local levels, which makes sense, since, as Blakely and Carbonell say, "the benefits of action - and the costs of inaction - will to a great extent, be felt locally."⁴⁵⁹ States have extensive regulations concerning coastal land use, and many are beginning to implement climate change adaptation in their regulations. All ten states in the North Atlantic have taken some action to adapt to climate change, but the degree to which planning has been formalized and implemented in law varies greatly. Eight of the ten states have prepared a formal climate adaptation plan of some type, with only New Jersey and Delaware behind. Maine, Rhode Island, Massachusetts and Connecticut are perhaps the farthest ahead, having adopted law that requires local governments to consider climate change in land use decisions.

Maine and Rhode Island law requires municipalities to address sea level rise in comprehensive plans. Maine requires towns discourage growth and impose restrictions on the density, size and location of coastal development with

459 Ibid.

specific consideration of climate change. Massachusetts and New York now require their environmental review statutes to require consideration of climate change, and Massachusetts statewide building code also requires buildings in a floodplain to be designed to withstand projected sea level rise.⁴⁶⁰ Connecticut also passed landmark legislation to address sea level rise. Connecticut's law amends its Coastal Management statute to require consideration of sea level rise, and it places significant restrictions on structural protection of coastal property. New York meanwhile now requires sea level rise to be considered when permitting decisions are made regarding potentially hazardous uses such as petroleum storage.

The Mid-Atlantic states have had less success at implementing legal provisions relating to climate change, but planning and studies are proceeding ahead, with Maryland and Delaware farthest ahead. Maryland recently passed a law to address sea level rise and coastal flooding impacts on capital projects planned and built or funded by the state.⁴⁶¹ Delaware's governor signed an executive order which requires state agencies to incorporate measures to adapt to sea level rise in siting and design of projects as well as to use green infrastructure when possible.⁴⁶² New Jersey and Virginia have completed planning exercises but not adopted any regulation impacting policy as of yet.

⁴⁶⁰ 310 Code of Mass. Regs. 9.37(2)(b)(2)

⁴⁶¹ Ibid. § 3-602.3 (b)(1)

⁴⁶² Ibid.

The use of federal recovery funding for buyouts of Sandy damaged properties was a substantial success, despite the program's major cutback. However, buyouts are not a particularly effective long-term strategy outside of disasters. As Laves and Waterman (2012) wrote, "the massive cost of coastal protection and relocation, even for small towns, may not be viable in the long term."⁴⁶³ Using regulatory approaches that allow communities to adapt incrementally and in a manner consistent with constitutional property rights are essential for successful climate change adaptation. Regulatory approaches such as land use tools are most likely to be successful at these aims because of their incremental nature and low cost, and also because of the sheer inadequacy of other options.

Using tools such as TDR and amortization can potentially reduce the costs, and increase the effectiveness and political acceptance of using land use strategies to adapt to climate change. The option of using TDR enhances private property rights, an important component to winning political favor for adaptation. TDR allows payment for a "buyout" without having to actually dip into the government's budget, and gives homeowners an option instead of forcing them to rebuild in a floodplain after a devastating storm. Constitutional issues are

⁴⁶³ Berry, Ashton and Peter Waterman, "Climate Change: Implications and Liability from Sea-Level Rise and Storm Surge on the Burnett Mary Regional Coastline," Working Paper 001/09, *Climate Change Coasts and Catchments, School of Science and Education*. University of the Sunshine Coast (2009) p. 218.

of no concern in a voluntary program, such as the post-Sandy program in New York. However, a program that prohibited redevelopment of flood-damaged homes would need to win an argument that government can amortize an inherently hazardous use. This argument has support in some states, but not all states follow this rule. TDRs might not satisfy compensation requirements if a taking is found, but those problems should not diminish their importance for enhancing the viability and fairness of adaptation programs.

Ultimately, many states and localities are utilizing their laws to adapt to climate change, and those that are most successful realize that protection of private property rights is an essential element to ensure resilient and sustainable coastal development.

CHAPTER 7-POST-SANDY ADAPTATION

7.1. INTRODUCTION

The data collection for this project finished up in September 2012, just before a small, late-season tropical storm spun up out of the Caribbean Sea and headed north – an unassuming start to what effectively change the course of history as it pertains to adaptation to climate change in the North Atlantic.

The storm, like thousands of others in the past, was expected to have taken the harmless route out to the open Atlantic, especially with the strength of prevailing westerlies in the mid-latitudes so late in the season. But an anomalously strong Bermuda high blocked the path out to sea, and 'Superstorm' Sandy took an unprecedented and what would prove to be historic route toward the mid-Atlantic coast.

Sandy tore a path of devastation through New Jersey and New York, and impacted surrounding states as well. 159 people in the United States were killed as either a direct or indirect result of Sandy and more than 650,000 homes were damaged or destroyed.⁴⁶⁴ Hundreds of thousands of businesses were damaged or forced to close at least temporarily and cost \$67.6 billion.⁴⁶⁵

 ⁴⁶⁴ NOAA, "Billion-Dollar Weather and Climate Disasters: Table of Events."
 <u>www.ncdc.noaa.gov/billions/events</u> (Accessed 12 April 2016)
 ⁴⁶⁵ Ibid.

An unprecedented opportunity exists in the wake of a storm to overcome the obstacles to implementing innovative hazard and climate change adaptive policies.⁴⁶⁶ Mileti also suggests that locally-driven planning after a disaster and integration with land use planning lead to greater effectiveness over time.⁴⁶⁷ Therefore, the storm could have provided a unique opportunity to introduce new long-term adaptation strategies.

In addition to the literature support, findings from the study presented in the previous chapters present suggestions for strategies to accomplish the most effective climate adaptation. The study suggests that communities should have focused on projects that generate the most benefits at the lowest costs, and implementable without external support. To accomplish this, we examined community recovery plans from Superstorm Sandy to assess the range of projects they chose to implement to foster resilience to coastal storms and sealevel rise.

7.2. THE STUDY

Six months after Hurricane Sandy struck the New York coast, New York Governor Cuomo announced an unprecedented program to fund local, community driven recovery plans, called the New York State Rising Community Reconstruction Zone (CRZ) program. The program was established

⁴⁶⁶ Titus, "Planning for Sea Level Rise."

⁴⁶⁷ Mileti, Dennis. *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Joseph Henry Press, 1999.

to enable communities devastated by Hurricane Sandy and Tropical Storms Lee and Irene to "identify resilient and innovative reconstruction projects and other needed actions based on community driven plans that consider current damage, future threats, and the community's economic opportunities."⁴⁶⁸ The program presented an opportunity not just to recover from the storm to a baseline condition, but to incorporate long-term resilience thinking into recovery planning.

A total of 50 CRZs, encompassing 102 localities, were designated to receive assistance and funding to prepare a plan, and 45 of these prepared a CRZ plan in round one. Each CRZ community established a planning committee that included, elected legislative representatives, local residents, and leaders of other organizations and businesses in the community. The state provided assistance by providing \$25 million from the CDBG recovery funds for consulting firms to help draft plans and provide experts and facilitators for the community meetings and workshops. After eight months of analysis and meetings, each committee finalized a plan. Plans were expected to address a number of specific issues in order to enable projects to receive implementation funding. The plans had to include an assessment of risk and vulnerability, focus on restoring and enhancing the resilience of key assets, ensure projects

⁴⁶⁸ N.Y.S. Office of Storm Recovery, "NY Rising Community Reconstruction Program Overview."<u>http://stormrecovery.ny.gov/sites/default/files/documents/NY-Rising-Community-Reconstruction-Program-Overview.pdf</u>

had potential for co-benefits to local economies, emphasize protecting vulnerable populations, address regional coordination, and include effective implementation guidelines. Each plan includes a list of transformative projects and actions, which were meant to be considered for funding by local, state, federal and private resources, and it is the nature of those projects that we focus on assessing. The 1431 proposed, featured and additional projects span enormous areas of policy from road maintenance, to education and vocational training, to comprehensive land use plans, to installation of generators. For the purpose of analysis, we focused on proposed and featured projects, as the projects in the additional category were not as thoroughly assessed. The total monetary value of the 840 proposed and featured projects was more than \$2.5 billion. Average project costs of each community varied with a median of \$750,000 and a standard deviation of \$1,673,095.

The reconstruction plans were designed to emphasize a multi-prong approach to recovery. The plan guidance provided by New York State instructed communities to "identify resilient reconstruction and other needs...that consider current damage, future threats and...economic opportunities." ⁴⁶⁹ Although the plans were designed to allocate federal funding for recovery, the resulting plans were not solely funding-focused documents. Plans were to consider past storm damage, the context for redevelopment, and other

⁴⁶⁹ Ibid, 4.

components of resilience, such as economic capacity and social justice issues. The state emphasized the importance of generating and enhancing the cobenefits of resilience, sustainability and economic development. It also emphasized the goal of long-term, locally-led resilience in its planning guidance and encouraged plans and projects that not only allocate funding, but achieve a broader goal of creating self-empowerment and independent, longterm resilience. One question this research sought to answers was whether that goal was achieved.

7.3. METHODS

A total of 50 community reconstruction zones (CRZ), encompassing 102 localities, were designated to receive assistance and funding to prepare a plan. 45 of these prepared a N.Y. Rising Community Reconstruction Plan in round one, and five counties prepared a countywide resilience plan.⁴⁷⁰

Each CRZ community established a planning committee that included elected legislative representatives, local residents, and leaders of other organizations and businesses in the community. The state provided assistance by providing \$25 million from the CDBG recovery funds for consulting firms to help draft plans and provide experts and facilitators for the community meetings and

⁴⁷⁰ In January 2014, Governor Cuomo expanded the program to an additional 22 localities. We analyzed the 45 CRZs which were completed by June 2014, when the data was analyzed and collected.

workshops. State guidance specified the content of the plans, which was to "provide a vision for the community, an analysis of assets at risk, an assessment of needs and opportunities, strategies to address those needs and opportunities, and measures to implement those strategies."⁴⁷¹

Each plan includes a list of transformative projects and actions, which were meant to be considered for funding by local, state, federal and private resources, and it is those projects that we focus on assessing. The 1431 proposed, featured and additional projects span enormous areas of policy from road maintenance, to education and vocational training, to comprehensive land use plans, to installation of generators. The total monetary value of the 840 proposed and featured projects was more than \$2.5 billion. Average project costs of each community varied with a median of \$750,000 and a standard deviation of \$1,673,095. For the purpose of analysis, we focused on proposed and featured projects, as the projects in the additional category were not as thoroughly assessed. A set of qualitative and quantitative criteria was designed to categorize and assess the projects, culled from the academic literature, the state's project criteria, and criteria from other jurisdictions.

The qualitative measures include the following:

- 1. Regional Status (Yes, No)
- 2. Featured (Proposed, Featured, Additional)

⁴⁷¹ N.Y.S. Office of Storm Recovery, "Planning to Succeed." Presentation. <u>http://stormrecovery.ny.gov/sites/default/files/documents/Planing_to_Succeed.pdf</u>

- 3. Project Category (Community Planning and Capacity Building, Economic Development, Infrastructure, Natural and Cultural resources)
- 4. Consistency with NYRCR (Increase resiliency of key assets, coordinate with regional initiatives, drive economic growth, address short medium and long term risks, Protect Vulnerable Populations)
- 5. Term (Short/Emergency, Medium, Long)
- 6. IPCC Strategy (Retreat, Accommodation, Protection, Procedural, Prevention, None)
- 7. Type (Administrative, Law, Plan, Capital Investment, Pilot Project, Study, Education/Capacity Building)
- 8. Project Management Tool (Green Infrastructure, Gray Infrastructure, Buildings/Structures, Land Use Planning, Fiscal Tools, Education)

The quantitative measures, constituting the benefits score, include the following:

- 1. Climate Change Adaptation benefits
- 2. Climate Change Mitigation benefits
- 3. Environmental benefits
- 4. Economic (cost savings) benefits
- 5. Economic Development benefits
- 6. Vulnerable Populations / Social Justice benefits
- 7. Health and Human Services benefits
- 8. Flood Risk reduction benefits
- 9. General Risk reduction benefits

The criteria for the benefits score includes the legal requirements of Community Development Block Grant – Disaster Recovery (CDBG-DR) funding, the state's NY-Rising project criteria as applied by the local committees, as well as criteria from other jurisdictions and the academic literature. The state's criteria cover a variety of functions such as Community Planning and Capacity Building, Economic Strategies, Health and Human Services Strategies, Housing Strategies, and Infrastructure Strategies, e.g. to reduce risk, to impact critical facilities, costs (availability of funding and timing, life-cycle costs, costs to residents, costs to municipality), value to the community, benefits to the environment, benefits to economic opportunity, benefits to strengthening social assets, and acceptability to the community. In addition, we used criteria from the literature, which suggests a number of broad categories by which we can measure and thereby prioritize vulnerability and risk reduction solutions.

For the purposes of this chapter of the dissertation, we focus specifically on the Project Management Tool, IPCC strategy, and Type categories. The total benefits scores were not weighted, following the admonition of Opricovic and Tzeng: "equal importance weights, wi=1/n, should be used when there is no information from the decision maker or when there is not enough information to differentiate the relative importance of criteria." ⁴⁷² Due to the lack of weighting information, the categories were assigned equal weights for the purpose of measuring overall benefits.

⁴⁷² Opricovic, Serafim and Gwo-Hshiung Tzeng. "Fuzzy multicriteria model for postearthquake land-use planning." *Natural Hazards Review* 4, no. 2 (2003): 59-64, 61.

7.4. RESULTS

7.4.1. Summary by IPCC+2 Category



Figure 29 - Distribution of total costs (left) and median cost (right) by IPCC category The projects were classified on a number of criteria, including the Intergovernmental Panel on Climate Change +2 explained previously in this dissertation (IPCC+2). The categories include accommodation, prevention, procedural, retreat, and protection.



Figure 30 – Project frequency and benefits by IPCC+2 strategy

Accommodation projects are actions that strengthen the resilience of existing or new structures but do not attempt to prevent flooding or advance of the sea. There were 434 accommodation projects, which had a median cost of \$950,000 and a sum cost of approximately \$1.2 billion (65% of the total). Accommodation projects had an average benefits score of 7.7.

Prevention projects are actions taken to protect or preserve land its natural state that prevent exacerbation of coastal hazards. Projects such as land conservation programs, coastal setbacks, and wetlands buffers are defined as prevention. There were eight prevention projects, which had a median cost of \$2.55 million and a sum cost of \$39.4 million (2% of the total). Prevention projects had an average benefits score of 14.6.

Procedural projects are studies, mapping exercises, administrative or educational programs, or those projects that incorporate climate change considerations into other administrative processes. There were 136 procedural projects, which had a median cost of \$295,000 and a sum cost of approximately \$128 million (7% of the total). Procedural projects had an average benefits score of 7.1.

Retreat projects are actions taken to shift coastal development landward and restore natural ecosystems, such as buyouts, transfer of development rights programs, and creation and establishment of new public parks. There were 40 retreat projects, which had a median cost of approximately \$1.3 million and a sum cost of approximately \$122 million (7% of the total). Retreat projects had an average benefits score of 11.9.

Protection projects are actions taken to keep floodwaters out of communities. These may be adjustments to hard structures such as elevating dikes and sea walls or soft solutions including beach nourishment projects. There were 145 protection projects, which had a median cost of \$990,000 and a sum cost of approximately \$313 million (17% of the total). Protection projects had an average benefits score of 7.7.

Accommodation is clearly the vastly preferred strategy, representing more than 65% of projects by proposed spending and 57% by count. Accommodation is also relatively low-cost, as the second-to-least cost category of the five, with a median cost of just under \$1 million.

7.4.2. Summary by Project Management Tool



PROJECT MANAGEMENT TOOL FREQUENCY AND BENEFITS

Figure 31 - Project frequency and benefits by project management tool

The CR Guidance for New York Rising Community Reconstruction Plans identified six classes of management measures that reduce the exposure and vulnerability of assets to storm impacts. The state guidance specified that strategies should be developed for each type of asset within a recovery support function. We modified these categories to better capture the range of projects communities had proposed. The categories are defined as: Education, Fiscal Tools, Buildings/Structures, Land Use Planning, Green Infrastructure, Gray Infrastructure and Green and Gray Infrastructure combined. We focus on land use planning and management strategies – those that involve reduce exposure by studying or directly altering regulations pertaining to the private management and use of land, such as buyouts, setback regulations, vegetation preservation requirements, zoning and subdivision codes, as well as special laws such as wetlands regulations.

Land Use Planning and Management projects represented 18% of all projects by total spending with a median project cost of \$750,000, about average for all management tools. Land Use Planning and Management represented 14% of projects by count – a total of 118 proposed and featured projects that used land use planning techniques exclusively. Land Use Planning projects also had the second highest benefits score of all project management tools.

The state emphasized the importance of land use tools in its guidance document. The state wrote that "incorporating sustainable measures and environmental services of natural protective features in land use plans can enhance community value, making communities safer while lowering costs...and can facilitate community health."⁴⁷³ The state also emphasizes that land use planning is not just about where not to build, but about where to build

⁴⁷³ New York State. *Guidance for New York Rising Community Reconstruction Plans* (March 2014). Six Classes for Management Measures.

http://stormrecovery.ny.gov/sites/default/files/documents/Guidance_for_Community_Reconstr uction_Plans.pdf, 46

safely. As an example of such an action, it says, "Change zoning to allow multifamily housing in more residential areas or floor area ratio bonuses for green commercial buildings, and wetlands regulations."⁴⁷⁴ The state also emphasized the role that land use plays in natural buffers and conservation of hazardous and environmentally sensitive areas, as a complementary strategy to acquisition and restoration.^{475.} Many land use regulations, including most suggested here, implement prevention actions in the IPCC+2 classification system. But land use can also include actions that effectuate retreat, such as through transfer and purchase of development rights, also suggested by the state. However, no projects proposed such actions in any CR plan.

7.4.2. Stormwater and Site Planning Ordinances

Some communities did include a substantial focus on land use issues. Jay and Keene, located in the Adirondacks of northern New York State, proposed four projects that involve using local ordinances and land use planning to minimize stormwater pollution and shift development out of its floodplain. As the town explained in its plan:

Some of the impacts of Hurricane Irene and Tropical Storm Lee could have been avoided if development had not taken place in the floodplain and if permanent stormwater controls were installed in all developed area...the Planning Committee recognizes that future problems can be minimized through a strategy of smart planning and carefully designed local ordinances.⁴⁷⁶

⁴⁷⁴ Ibid., 35.

⁴⁷⁵ Ibid.

⁴⁷⁶ Town of Jay and Keene, New York Rising Community Reconstruction Plan. (2014), 51. <u>http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/jay-keene_nyrcr_plan.pdf</u>

The proposed projects include a study to identify land use regulatory changes to protect undeveloped hazardous areas and permit development in safer areas, a conservation easement program, as well as a study to modify site plan review ordinances to reduce development impacts on erosion and sedimentation.

7.4.3. Enhanced Site Plan Review

After reviewing several options, the CR committee in Jay/Keene decided that enhancing site plan review was the best way to improve regulation of stormwater runoff in the community. During Hurricanes Irene and Lee, poorly managed stormwater caused erosion, road failure and property damage.^{477.} The plan cites the problem that developers have not had to install permanent best management practices in areas of less than one acre. The very steep slopes which characterize Adirondack towns can fail due to heavy rainfall, as occurred during Irene, destroying houses and putting residents at risk. This project consists of hiring a consultant to review existing site plan laws, identify model ordinances to prevent erosion and sedimentation during and after construction, develop a steep slopes and geological risk overlay, and propose amendments to site plan review laws.

⁴⁷⁷ Ibid., 74-76.

7.4.4. Rezoning/Reclassifying Hazardous Areas

The CR plan in Jay/Keene also featured a project to reclassify land in the hamlet of Au Sable Forks. Jay and Keene are located in the Adirondack Park, and the Adirondack Park Land Use and Development Plan (APLUDP) has a heavy role in determining land use. The designation of "hamlet" in the APLUDP allows for growth.⁴⁷⁸ According to the CR plan, multiple community members expressed the opinion that the limited land area classified as 'hamlet' under the APLUDP was a constraint to economic growth and encouraged development in hazardous areas, such as floodplains, wetlands and steep slopes. The project proposed to study reclassifying hazardous areas as non-hamlet and locating non-sensitive areas upland for expansion of the downtown.

In an alternative strategy with similar results, the Village of Freeport on Long Island proposed a study to assess the potential for enhancing the development of a pedestrian friendly, transit-oriented downtown that is outside of high risk areas. The study, which assesses redevelopment potential within one-half mile of its Long Island Rail Road station, also considers access to local transportation and optimization of parking.⁴⁷⁹ The town intends to encourage development of underutilized parcels currently functioning as surface parking, and includes construction of a resilient parking garage to replace some of the

⁴⁷⁸ Ibid., 77.

⁴⁷⁹ New York Rising Community Reconstruction: Village of Freeport. (March 2014), 136-137. Retrieved from:

http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/freeport_nyrcr_plan.pdf

lost street parking as well as to provide a safe place for residents to store cars in the event of storm. The study will also consider development opportunities for housing and commercial space that would assist in the relocation of residents and businesses from higher risk areas. It provides multiple benefits on many measures, including economic development, cost savings, risk reduction, flood risk reduction, vulnerable populations, environmental performance, and climate change mitigation and adaptation.

7.4.5. Conservation Easements

Purchasing conservation easements are another way that governments can reduce risk by limiting development potential in hazardous areas without having to shoulder the expenses associated with buyouts. Jay/Keene proposed a featured project to permanently protect intact floodplain areas from development by purchasing conservation easements or purchasing development rights. The committee recognized that, "by keeping floodplain intact and connected to the river...Jay and Keene can preserve a tremendous flood protection asset." ⁴⁸⁰ Currently undeveloped open spaces and natural areas provide multiple flood protection benefits, including absorbing floodwaters, reducing peak downstream flows and capturing large debris during Irene and Lee. The project requires collaboration between land trusts, local and state entities. The total costs are capped at \$750,000, though government and non-profit support are expected to be provided in-kind. The

⁴⁸⁰ Towns of Jay and Keene CRZ Plan, 91.

project will have an incredibly valuable benefit to the local environment, protecting riparian habitat in perpetuity and improve water quality, as well as benefits to health and safety. Economic benefits include reduction of future property damage and potentially increase tourism revenue.

7.4.6. Combining Land Use Planning and Shoreline Protection Strategies

Hundreds of projects proposed in the CR plans use single-minded infrastructure solutions that protect vulnerable shorelines. But a few that used the tools of land use planning stood out as comprehensive, thoughtful and long range. One example is the Village of East Rockaway's Downtown Resiliency and Redevelopment Strategic Plan.⁴⁸¹ The plan proposes to identify solutions for reinforcing economic development and flood protection together, serving as a redevelopment plan to guide future zoning changes as well as streetscape and shoreline improvements. This project leveraged the area surrounding the Talfor Boat Basin as a unique waterside destination to diversify and strengthen the commercial base and provide new housing opportunities. For the low cost of \$195,000, the project provides climate adaptive benefits, reduces the risk of flooding, and enhances economic development.

⁴⁸¹ New York Rising Community Reconstruction: Bay Park and Village of East Rockaway. (March 2014). Downtown Resiliency and Redevelopment Strategic Plan. <u>http://stormrecovery.ny.gov/sites/default/files/crp/community/documents/baypark-eastrockaway_nyrcr_plan_low_res.pdf</u>

7.5. CONCLUSIONS

Many communities recovering from Sandy are now facing the repercussions of decisions made by their forebears to be located directly on coastal and riverine floodplains. A century ago, the costs and benefits of building in floodplains and near shorelines were very different. Climate change risks were nonexistent, and waterborne shipping and transit were the primary mode of transport of goods and people. Today, of course, the factors in this land use equation are very different. While many communities see themselves as "built out," the reality is that there is still much development and redevelopment occurring.

Yet, despite the availability of strategies that have little or no cost, such as land use planning, such projects were relatively rare in the Sandy recovery plans. The lack of emphasis on land use strategies is explicable on a number of grounds - many CR communities, such as those in New York City, do not have jurisdictional control over their zoning and building codes, since those powers lie with a larger government than the individual neighborhoods. Local council members can, of course, make introductions for new laws, but the process is complex and lengthy. But other jurisdictions, including those on Long Island and upstate, have more direct control over their local laws, and yet the use of land use measures to increase resilience were rare. This may have had to do with the fact that elected officials were infrequently represented on CR committees, and their work proceeded separately from official activities of the cities, towns and villages. A greater emphasis on these strategies in the implementation phase along with required coordination would go a long way toward enhancing the recovery plans' long term effectiveness.

Burby (2006) argues that the trend in increasing numbers and severity of disasters are the predictable outcomes of well-intentioned, but short-sighted, public policy decisions that create a paradox.⁴⁸² By improving safety and resilience of hazardous areas, he suggests, policies have made them targets for catastrophes. Infrastructure of any type can have this effect, since it increases the perceived safety of the area and encourages further investment. As Burby notes, this is sometimes intended: "As the experience of New Orleans illustrates, federal policy has had its intended effect of facilitating and sustaining development in hazardous areas." 483 Burby argues that "the political considerations of the President and Congress that create the safe development paradox are not likely to change. Federal assistance following disasters is likely to increase with increasingly severe disasters, as will federal efforts to make places at risk safer communities in which to live and work."484 He says that what can change is better local government decision making that does not perpetuate urban development of at risk structures in vulnerable places by using the tools of land use planning. Land use strategies

⁴⁸² Burby, Raymond J. "Hurricane Katrina and the paradoxes of government disaster policy: Bringing about wise governmental decisions for hazardous areas." *The Annals of the American Academy of Political and Social Science* 604, no. 1 (2006): 171-191.
⁴⁸³ Ibid., 176.
⁴⁸⁴ Ibid., 172. fundamentally reduce risk in a comprehensive and long-term manner instead of using expensive and fallible infrastructure to band-aid vulnerabilities.

CHAPTER 8-CONCLUSIONS

A mixed-methods study to inventory low-cost, local climate change adaptation best practices in Northeast coastal communities revealed that the communities are taking action with a variety of innovative tools, such as comprehensive planning, zoning and building codes, as well as education initiatives and implementing green and gray infrastructure projects. They are motivated to take action to increase community safety and respond to constituent concerns, and the negative politics of climate change are not a significant barrier. Formal climate change planning, which often involves modeling future sea level rise that predicts impacts on communities, results in little discernible action. However, communities are taking action outside of formal climate change studies, and much of this action is incremental change in existing laws and procedures. Far more commonly than using conventional solutions such as gray infrastructure, communities are primarily adopting low-cost procedural tools such as comprehensive planning and accommodation and prevention strategies such as land use regulations and building codes.

The widely-cited IPCC 1990 adaptive action classification system is inadequate.⁴⁸⁵ The Intergovernmental Panel on Climate Change identified

⁴⁸⁵ Intergovernmental Panel on Climate Change 1990.

three types of strategies to adapt to sea level rise: accommodation, protection, and retreat. Many adaptations, notably most planning activities, do not fit these three, and hence the study suggests two new categories: prevention and procedural. Overall, communities potentially have the tools necessary for effective adaptation to climate change, and land use and planning are critical to climate change adaptation because they are affordable, effective, replicable tools enforced through law. Lastly, evaluation of post-Sandy projects demonstrate that more attention needs to be paid to these low-cost, effective and replicable tools in disaster recovery.

8.1. COMMUNITIES ARE TAKING ACTION, MOTIVATED BY SAFETY AND PROTECTION, AND THE POLITICS OF CLIMATE CHANGE IS NOT A SIGNIFICANT IMPEDIMENT

Municipalities have been dealing well with the present political situation, even though it makes climate change response into a partisan war. With the notable exception of Virginia, where the political circumstances were hostile to climate change action, municipal staff interviewed nearly universally suggested that they saw no significant opposition to climate change action. In fact, a quarter of local adaptations were reportedly initiated in response to constituent concerns.

One way communities deal with the uncertainties of climate prediction and the potential political controversy is by basing the regulatory rationale on present climate risk. For instance, the Coastal Erosion District ordinance in East Hampton, New York regulates and limits the placement of shoreline hardening
structures such as groins and seawalls in most parts of the town and prohibits new private coastal erosion structures. The findings and objectives of the law explicitly mentions climate change, stating:

Changes in climate [global warming and the "greenhouse effect"] may exert an influence on future storm activity and also cause sea-level to rise, with profound effects on the Town's coast. Such changes would render these natural protective features all the more important. In any case, while future sea level rise and increased storm activity may be uncertain, it is well established that present sea level is rising and statistically certain that storms will be an ever-present threat to the Town's coastal zone.⁴⁸⁶

Similarly, East Hampton's Local Waterfront Revitalization Plan (LWRP) states that climate factors "point to an increasing risk of flooding and erosion in coming years, and a need for planning procedures better adapted to receding shorelines and more frequent catastrophic storms."⁴⁸⁷ Present risks are good justifications for sometimes costly adaptations, and basing legal language on present risk is a sounder ground for regulation. As states are beginning to pass laws to take action as well, this approach may become less necessary. In the same vein, adaptive actions can sometimes achieve other community goals.

Although many assume that communities usually will not act on climate change without external motivation such as state legal mandates or funding sources, we found otherwise. Communities are mainly motivated to protect

 $^{^{486}}$ Town of East Hampton, N.Y. Code § 255-3-80

⁴⁸⁷ Town of East Hampton, N.Y., Local Waterfront Revitalization Plan, p. V-17

themselves and their environment, and respond to constituent demands. They appear less likely to act because of elected officials or external incentives such as funding availability or the FEMA Community Rating System (CRS). At the same time, communities rated external funding as one of the most important factors in increasing the effectiveness of adaptations.

These results generally comport with the literature, including a recent metaanalysis conducted by Hughes, who looked at motivations for climate adaptation planning across more than 50 studies.⁴⁸⁸ Consistent with the findings here, she wrote, "Urban climate change adaptation planning is most often framed as a necessary strategy for protecting the city's assets and reducing the city's vulnerability to hazards and disasters."⁴⁸⁹ Citizen demand and external funding were found to be insignificant motivators for climate adaptation action. She laments that a side effect of this pattern is that "adaptation is focused on protecting physical assets and rarely incorporates equity, social vulnerability, or the effect of non-climatic conditions."⁴⁹⁰

Both the present study and Hughes' meta-analysis do not necessarily generalize to all municipalities, since samples explicitly choose communities taking self-directed action. Those not acting proactively are probably more

⁴⁸⁸ Hughes, "A meta-analysis of urban climate change adaptation"

⁴⁸⁹ Ibid., 6.

⁴⁹⁰ Ibid.

subject to external incentives. Officials in some communities, such as Crisfield, Maryland, a working-class fishing town on the Eastern Shore of Maryland, expressed the concern that local government would not act without state or federal mandates or incentives. Many communities in our study have floodplain codes that simply meet minimum federal standards, emphasizing the need for FEMA regulations to keep pace with increasing climate change threats. For some towns, FEMA's Community Rating System is the key adaptation toolkit, and it has great support among elected officials in places such as Sea Isle City, New Jersey, where the mayor made obtaining a high score his singular priority. CRS may have motivated the town, but on its own the town took the unprecedented step of enforcing its building code by summonsing homeowners non-compliant with new flood venting requirements. Still, many communities do not participate in CRS and some had not even heard of it, suggesting FEMA needs to do more outreach to publicize the program and ensure it responds to municipal needs.

8.2. COMMUNITIES ARE TAKING INCREMENTAL, EFFECTIVE ACTION

Despite fears that climate adaptation will be a complex, costly effort that will disrupt lives and communities, the study revealed that approaching planning through small and incremental steps accomplishes a great deal. Communities often do this by incorporating climate change into existing planning processes, such as hazard mitigation or comprehensive planning. A fifth of the actions inventoried involved incorporating climate change or sea level rise into another plan, suggesting that this technique is spreading.

The ability to tie climate change planning into existing planning protocols such as Hazard Mitigation Planning is essential. In a paper exploring the linkages between disaster management, climate change adaptation, and land use planning, Barjracharya, Childs and Hastings wrote, "Climate change will manifest in altered regimes of natural hazard occurrence, and therefore can be conceptualized as a disaster management issue." 491 Hazard mitigation planning (HMP) is a convenient vehicle for implementing climate change adaptation, since every five years, local governments review and update HMPs, as required by the Disaster Mitigation Act of 2000.⁴⁹² The universality of HMPs make them a good target for incorporating climate change adaptation incrementally and nationally. Indeed, many communities in our sample incorporated climate change into their HMPs, including Barnstable, Massachusetts, Brewster, Massachusetts, Guilford, Connecticut, New Haven, Connecticut, Poquoson, Virginia, and Lewes, Delaware. Lewes' plan suggests that incorporating climate change into their HMP was a cost-efficient strategy.

⁴⁹¹ Bajracharya, Bhishna, Iraphne Childs, and Peter Hastings. "Climate change adaptation through land use planning and disaster management: Local government perspectives from Queensland." In *17th Pacific Rim Real Estate Society Conference*, pp. 16-19. Pacific Rim Real Estate Society, 2011.

http://www.prres.net/papers/Bajracharya Childs Hastings Climate change disaster manag ement_and_land_use_planning.pdf

⁴⁹² 44 C.F.R. § 201.6.a (4)

The plan explains: "[A] major reason to begin enhancing Lewes' hazard mitigation efforts with climate change adaptation is that proactive planning is often more effective and less costly than reactive planning, and can provide immediate benefits."⁴⁹³ In addition, climate planning itself, the city wrote, "will lead to actions that are cost-effective and will save municipal budgets in the future."⁴⁹⁴

Incorporating climate adaptive goals into comprehensive plans is also an effective means of shifting incrementally. The significance of comprehensive plans varies across states. In the study sample, Rhode Island, Massachusetts, and Delaware are the only states that require implementation of comprehensive plans, although all states studied allow their towns and cities to do so voluntarily. In most states, comprehensive plans are not explicitly enforceable, but instead guide future decision making. In this way, incorporating climate change into the town plan often becomes an essential first step in gaining acceptance, as happened in Greenwich, Connecticut, Marshfield, Massachusetts, Southold, New York, Worcester County, Maryland, York, Maine, Ogunquit, Maine, Sea Isle City, New Jersey, and Hampton, New Hampshire.

⁴⁹³ Lewes, Delaware, Hazard Mitigation and Climate Change Adaptation Action Plan, at 9.⁴⁹⁴ Ibid.

As an example of a community that incorporated climate change into its master plan, Hampton's master plan discusses the impact of sea level rise and climate change on the town's vulnerability to coastal flooding.⁴⁹⁵ As with most comprehensive plans, the text is aspirational and makes recommendations not legally enforceable. Hampton's plan makes recommendations for future action, such as regulations to enhance flood controls, stricter building codes in flood areas, and similar actions that change the types of structures built near in high-velocity wave areas.

Sea level rise is also addressed in parts of York, Maine's current comprehensive plan, and the town is currently drafting an entire chapter on sea level rise for its upcoming plan update. The current plan contains a sea level rise subsection, as well as a specific goal to implement strategies to adapt to it.⁴⁹⁶ The plan also frames the goal of coastal sand dune protection as a bulwark against sea level rise.⁴⁹⁷ Although aware that other towns had made code changes to respond to climate change, York's town planner thought it was important for the town to address it in the comprehensive plan first.

⁴⁹⁵ Hampton, N.H., Hampton Beach Master Plan, Sec. III-104
⁴⁹⁶ Ibid., Natural Resources Chapter. 6
⁴⁹⁷ Ibid., p. 39

8.3. LAND USE AND PLANNING ARE CRITICAL TO CLIMATE CHANGE ADAPTATION BECAUSE THEY ARE LOW COST, EFFECTIVE, REPLICABLE TOOLS ENFORCED THROUGH LAW

The literature posits that most climate change planning results in little discernible action. Wheeler studied climate change plans in all states with climate planning documents and all cities with a population over 500,000 that are members of the Cities for Climate Protection campaign, and found that they mostly lacked the actions and political and institutional commitment needed to mitigate or adapt to climate change.⁴⁹⁸ Hughes agrees that most current adaptation planning focuses on assessment of hazards and vulnerabilities rather than project implementation.⁴⁹⁹ However, this study found that climate adaptive activity is being implemented, although most often outside of formal climate change planning activities. Of projects in the sample, more than 40% of actions are mandatory and enforceable by law, and another 12% were directly implemented, demonstrating actions and institutional commitment to climate change adaptation. Moreover, although often underrecognized for its essential role in climate change adaptation, the study found that land use planning, and its complement building regulation, play a critical role in adaptation, given their low costs and high effectiveness. As depicted in the figure below, land use is the most frequently adopted subtool in our sample.

⁴⁹⁸ Wheeler, "State and municipal climate change plans"

⁴⁹⁹ Hughes, "A meta-analysis of urban climate change adaptation"



Figure 32 - Capital Investment, Law, and Plan Subtypes frequency, effectiveness, replicability and cost

Contrary to popular perception, land use planning mandates adaptation, and does not result in dust-collectors. Land use and building code strategies are the most frequently implemented mandatory actions. Building code regulations were rated the highest in effectiveness of any of the subtools. Although directly implementing green infrastructure was rated as more effective than land use regulations, infrastructure projects tend to be much more expensive, complex, and require large external investments, and are therefore much less likely to be actually implemented. Gray infrastructure had the highest cost of all project subtypes, and was on average seen as least effective and replicable of the tools. As is depicted in the figure above, green infrastructure, building codes, land use regulations, fiscal strategies, and all types of plans were all more effective and replicable than gray infrastructure. Land use actions that mandate compliance include vegetation ordinances, wetland buffers, subdivision regulations, and zoning codes. Most types of plans, such as hazard mitigation plans and floodplain management plans, by themselves do not mandate action. Some, however, including Hull, Massachusetts' Beach Management Plan, and Local Waterfront Revitalization Plans in New York State do create it.

The Waterfront Consistency Review process of New York State requires under state law that any town with an adopted LWRP review its actions in the coastal area for consistency with the LWRP and coordinate review with the NYS Department of State regarding federal and state actions. If the action is inconsistent, an applicant may need to modify their project or risk denial of permits. Towns can incorporate climate change issues into their LWRP and thereby create an enforceable climate change adaptation policy. An example of a plan that incorporates sea level rise and climate change is the Town of East Hampton's LWRP, which sets a priority goal to maintain natural protective features, bluffs, dunes, wetlands and native vegetation. ⁵⁰⁰ The town's comprehensive plan incorporated the LWRP and the town board adopted zoning to implement the comprehensive plan, incorporating the need to protect natural features called for in the LWRP, which also served as the basis for the

⁵⁰⁰ Town of East Hampton LWRP, p. V-17

new zoning classifications. ⁵⁰¹ The town has the authority to mandate compliance with its LWRP, thereby making climate change adaptive land use planning enforceable law.

Perhaps even more significantly, New York City is similarly incorporating climate change into its LWRP. Called Vision 2020, New York City's LWRP considers the impact of climate change and identifies strategies for addressing rising sea levels and more frequent and severe storms.⁵⁰² Proposed changes to the city's LWRP "will solidify New York City's leadership in the area of sustainability and climate resilience planning as one of the first major cities in the U.S. to incorporate climate change considerations into its coastal zone management plan."⁵⁰³ Current law establishes the boundary of the coastal zone at the 100-year floodplain, and the new LWRP expands its jurisdiction to the 500-year floodplain. Expansion of the LWRP jurisdiction means that the LWRP and its consistency review requirements will apply in the expanded zone. This change effectively mandates the more stringent review within the area projected to become the 100-year floodplain in the next century. The LWRP itself requires assessment of climate change impacts in projects proposed in the LWRP zone, meaning that all projects will have to assess their vulnerability to sea level rise, coastal flooding and storm surge, and

⁵⁰¹ Ibid., Introduction p. 11

⁵⁰² City of New York, Department of City Planning, (2012). Vision 2020 Comprehensive Waterfront Plan., 7 ⁵⁰³ Ibid 107

⁵⁰³ Ibid., 107

incorporate measures to reduce those risks to the maximum extent practicable. Most land use law that is climate adaptive, such as zoning provisions that mandate freeboard, is relatively static. These LWRP provisions are dynamic, in that they create a type of "constitution" for coastal zone planning, so that applicants will have to comply with their provisions far into the future.

Ogunquit, Maine offers another example of a dynamic adaptation enforceable by law by using a unique legal method to increase its shoreline setback without changing the setback itself, but rather by amending the definition of "normal high water" that determines the setback. ⁵⁰⁴ The highest annual tide predicted for the region is generally about seven feet above mean high water. By amending its definition of "normal high water" to 11 feet above mean sea level, the town sets a margin of about four feet for sea level rise, which is also two feet higher than the FEMA 100-year designated floodplain.

Whether dynamic regulations such as East Hampton and Ogunquit's or the more traditional static type, land use has a critical role to play in ensuring resiliency and sustainability of coastal communities. Land use adaptations are easier to implement, more replicable and lower cost than most other types, and they are more often adopted by municipalities. In addition, they mandate action that ensures communities will become more resilient over time, as

⁵⁰⁴ Town of Ogunquit, Maine, Town Code, Art. 2, Definitions, p. 24

individuals renovate or construct new buildings, in the regular course of development and redevelopment of coastal neighborhoods.

8.4. THE IPCC SYSTEM OF CATEGORIZING ADAPTATION STRATEGIES IS INADEQUATE TO DESCRIBE THESE IMPORTANT AND IMPACTFUL STRATEGIES

The Intergovernmental Panel on Climate Change (IPCC) identified three types of strategies to adapt to sea level rise: accommodation, protection, and retreat. ⁵⁰⁵ One key conclusion is that many adaptations, notably most planning activities, do not fit within these three, and hence two new strategies were proposed: prevention and procedural. These two categories present the best chance for communities to become more resilient over the long term because they are readily and frequently adoptable, enforceable, and low-cost.

Prevention actions, those that preemptively thwart development, were included in the IPCC system under retreat, but they should be re-categorized as prevention to distinguish them from the often politically treacherous actions that imply displacement. Prevention actions are important, but not commonly adopted. In contrast, the study found that communities are most frequently adopting actions that should be included in the IPCC system in a new category, here called procedural. This category includes all actions that generate

⁵⁰⁵ Dronkers, J., Gilbert, J. T. E., Butler, L.W., Carey, J. J., Campbell, J., James, E.,...von Dadelszen, J. (1990). Strategies for adaptation to sea level rise (Report of the IPCC Coastal Zone Management Subgroup: Intergovernmental Panel on Climate Change). Geneva, Switzerland: Intergovernmental Panel on Climate Change

information or amend processes, plans, and laws. These types of activities are essential to adaptation over the long term, and include most long-range planning activities, incurring change over time through the normal process of decision making, building and rebuilding. They are so essential because they effect change in a way that makes adaptation standard or routine, much like how environmental protection has become institutionalized through laws and policies over the past forty years. Because they may not have immediately recognizable results, they are often ignored or de-emphasized relative to more visible projects, such as hard infrastructure, especially in post-disaster planning. Ignoring such strategies increases the likelihood that disasters of the future will be more deadly, harmful, and costly.

8.5. STUDY LIMITATIONS & DIRECTIONS FOR FUTURE RESEARCH

Because the study samples municipalities identified as innovative by experts and through a snowball technique, no conclusions can be drawn about average or typical climate change adaptations. The best practices information can help promote cross-fertilization of ideas across the region and beyond, but cannot give perspective on how common, extensive, or effective climate change planning has been across municipalities on the whole. Further work should investigate adaptation planning in a broader range of towns and cities. Generalizable conclusions also cannot be drawn regarding community motivations to act, because self-directed action was one of the study's inclusionary criteria. One would expect other communities to be much more responsive to federal and state incentives and mandates. Not all local governments are capable of taking initiative without guidance, incentives and mandates.

Because of geographic, political, and socioeconomic differences across locales, the range of adaptive strategies is diverse. While this can be considered a strength, as it allows localities to respond to unique local circumstances, the programs' ad-hoc nature is also a liability. Because the study's sample is small, data could not be stratified geographically, socioeconomically, or otherwise. A future larger sample would allow this possibility, which could improve the strength of recommendations for various types of communities.

In addition, the study sought only one response from each locality. More respondents would likely increase the data's validity and reliability. Ideally, effectiveness and replicability could be measured using on-the-ground rather than survey responses. A future study could qualitatively and quantitatively estimate adaptation strategies' benefits following a disaster, comparing outcomes in communities with stricter regulations and adaptation strategies with those that did not take such action. Future research could also improve data on costs by measuring costs for all actors, and not just for local government.

8.6. RECOMMENDATIONS AND FUTURE DIRECTIONS FOR CLIMATE CHANGE ADAPTATION

8.6.1. Partnership is essential for success

Local governments are on the forefront of responding to and preparing for coastal threats. They are more than willing and able to take on the task, and they recognize that partnership is necessary for successful planning. Simple measures to incorporate climate change into existing planning processes are nearly cost-free when led by town staff or citizen volunteers, but more sophisticated planning requires funding, technical assistance, and partnerships with other levels of government and NGOs. In particular, many communities do not have the data to plan effectively. Improving local-scale climate data and expanding partnerships between states, NOAA, and state coastal management departments is essential. An example of a successful partnership is Lewes, Delaware, which received funding from NOAA's National Sea Grant Climate Change Initiative to engage in a participatory process to develop one document integrating hazard mitigation and climate change planning. This town's approach creates a model for future planning, since hazard mitigation planning is already commonly done, as federal law requires.

Limitations in climate prediction data are also a significant impediment to further action on climate change. Although some adaptations do not require extensive modeled data, many towns lack information about the impacts of climate change. Many would agree with the recent Congressional General Accounting Office report that recommended the federal government provide more and better data to assist with long-term planning. This information would help towns and cities to take action for mandating and enforcing stricter requirements. For instance, FEMA flood maps enhanced with climate information could help towns incorporate it in their plans and codes. FEMA could incentivize adopting regulations that responded to such information by granting CRS credits.

FEMA should also be open to partnering with local government to improve flood mitigation outcomes. Many towns expressed frustration at the delays in the current roll-out of LIDAR-based data. Towns with the capacity to do so should be allowed to proceed with adopting new maps on their own. For example, Greenwich, Connecticut, has already produced its own LIDAR maps, and is verifying the remote data with on-the-ground surveys. Just as with towns' own plans, greater openness to community engagement and incorporation of local knowledge, if credibly administered, could help gain local support for new flood maps. In addition, because climate adaptation planning is nearly always a voluntary endeavor, many municipalities lack effective adaptations. The NFIP model of setting a floor and incentivizing higher standards is good, but both funding and technical assistance to achieve their goals. FEMA and states should complement independent action in towns by encouraging and supporting them, but they should also independently incentivize and require action.

8.6.2. Land Use Has Limits

Land use may be the most important low-cost tool to ensure widespread adaptation occurs, ranging from simple floodproofing requirements to sophisticated solutions such as Transfer of Development Rights schemes. Yet despite the fact that land use codes and regulations are essential adaptation tools, they do not always completely answer many communities' adaptation questions. Much of the work of adapting communities to climate change involves undoing past mistakes. Misguided or short-term thinking has resulted in the development of exactly the most vulnerable locations. Thus it is difficult to shift coastal land use trajectories for two reasons.

First, regulations that affect landowners are challenging to implement and will likely encounter stiff opposition from impacted individuals, who are already invested in their existing homes and communities. The more restrictive the regulation, the more challenging the implementation, inevitably involving legal issues such as takings and demand for compensation. Communities in vulnerable locations create entrenched interests supporting entrenched polices that ensure their continued existence at any cost. Land use policies reducing risks will see resistance from those seeking to maintain stability in the look and feel of such places. The U.S. does not have a history of strong coastal management, and this pattern is unlikely to change, particularly given the politics and long time horizon of climate change. Implementing climate change adaptation is likely to be a long-term, community-by-community struggle.

Second, land use regulations, and most codes and laws, are prospective and therefore do not have an impact on existing structures. Most homes significantly damaged in Sandy, for instance, were constructed far before FEMA's regulations took effect in the 1970s. Historic communities present special challenges. Communities with established, historic built environments may be especially heavily reliant on hard infrastructure to ensure their survival, as a result of the difficulties of flood-proofing historic buildings and the political opposition to retreat. Land use strategies can substantially assist, but cannot completely solve climate-change related problems in these, and indeed, all communities. To compound the problem, nearly all communities face risk to existing infrastructure, with astronomical costs for retrofitting or renovating roads, bridges, sewer systems, power plants, and transmission lines to endure a future of worsening coastal storms and sea level rise. Nevertheless, coastal towns and cities must make such investments and overcome the many political and legal challenges that threaten their future to remain viable, sustainable places to live and work.

8.6.3. Improving Planning for Adaptation

The devastation wrought by Superstorm Sandy and Hurricane Irene indicate that communities are still highly vulnerable. Although coastal communities face many challenges, the innovative action taking place in many towns and cities in the North Atlantic demonstrate that it is within their power and interest to adapt to climate change. Local innovations, from expanding public participation to using transfer of development rights, cluster and subdivision ordinances to set-back development from the shoreline, are within the capacity and grasp of almost all North Atlantic local governments. Adaptation will not be simple and it involves many tradeoffs, but the capacity and will to do so is clear; many are already imagining a bold future of sustainable, resilient coastal communities.

A P P E N D I X

A. Full Database

Municipality/ County	Adaptation	Practice Type	Subtype	Strategy	Phase	Incorpor ation of CC	Enforc. Strength	Costs	Funding Source	Motivations	Improve Effectiveness	Effectiv	Replic ability
Barnstable, MA	Zoning Law Explicitly Incorporates Sea Level Rise, Requires Freeboard and allows Height	Law	Law - Land Use	Accommodati on	Implemented	Yes	Mandatory	Zero	None	Response to Constituent Concerns	Education, State or Federal Legal Changes	2	1
Barnstable, MA	Comprehensive Plan - Incorporates Climate	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Mandatory	Very Low (<	None	To protect the community,	AI	2	2
Barnstable, MA	Hazard Mitigation Plan Incorporates Sea Level	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	Very Low (<	None	Other	All	2	NA
Barnstable, MA	Coastal Resource Management Plan	Plan	Plan - Other	Procedural	Completed	Yes	Advisory	Very Low (<	Other	Environmental/Resource Protection	Funding, Education, State or	2	2
Barnstable, MA	Climate Change Adaptation Project	Study/Pilot		Procedural	In Progress	Yes	Advisory	Low (<	NGO/	To protect the community	All	3	4
Bowers, DE	Buyout of Repetitive Loss Property and	Capital	Green Infrastructure	Retreat	Implemented	Yes	Implemented	Low (<	FEMA	Funding was available	Other	2	5
Bowers, DE	Renovation of Parking Lot and Replacement with Renovation Stational	Capital	Green Infrastructure	Accommodati	Proposed	No	Proposed	Low (<	State	Response to Constituent Concerns, To	Funding, Technical Assistance	5	5
Bowers, DE	Relocating Downtown through Rezoning to Less	Law	Law - Land Use	Retreat	Proposed	No	Proposed	Low (<		Elected officials advocated, Response	Technical Assistance	5	3
Bowers, DE	Vulnerability Assessment and Delaware Coastal Recificacy Action Plan	Study/Pilot		Procedural	Completed	Yes	Advisory	Medium (<	State	Funding was available, Response to	Technical Assistance, Funding	3	5
Brewster, MA	Minimum Lot Size Restricts Development in	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Zero	None	Response to Constituent Concerns	Funding, Education	2	4
Brewster, MA	Wetlands Buffers Includes Performance Standards and Saa Level Rise Considerations	Law	Law - Land Use	Prevention	Implemented	Yes	Mandatory	Medium (<	None	Environmental/Resource Protection	Funding, Education	4	4
Brewster, MA	Hazard Mitigation Plan Incorporates Sea Level	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	Low (<	None	To protect the community	Funding, Education	3	3
Brewster, MA	Water Resource Management Plan Incorporates	Plan	Plan - Other	Procedural	Completed	Yes	Advisory	High (<	None	To protect the community	Funding, Education	4	4
Crisfield, MD	Freeboard - 2 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	Zero	None	Other	Education, Technical Assistance	5	NA
Crisfield, MD	Comprehensive Plan Incorporates Sea Level	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Zero	None	NA	NA	NA	NA
Crisfield, MD	Maryland Coast Smart Rising Sea Level	Plan	Plan - Other	Procedural	Completed	Yes	Advisory	Very Low (<	NOAA, State	Funding was available. To protect the	State or Federal Legal Changes,	5	1
	Guidance	1882						\$1,000)	11000	Protection	lechnical Assistance, Funding		<u> </u>
East Hampton, NY	Community Preservation Fund (2% Real Estate Transfer Tax) for land conservation	Law	Law - Hiscal	Prevention	Implemented	NO	Mandatory	Zero	None	Response to Constituent Concerns, To protect the community, Environmental/ Resource Protection, To reduce development pressure	Other	4	4
East Hampton, NY	Vegetation Preservation Ordinance: Turf grass Setback and prohibition of disturbance	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Zero	None	Response to Constituent Concerns, To protect the community, Environmental/ Resource Protection	Education	2	4
East Hampton, NY	Coastal Overlay District (Strictly regulates placement of hard infrastructure by 4 zoning categories)	Law	Law - Land Use	Prevention	Implemented	Yes	Mandatory	Zero	None	Response to Constituent Concerns, To protect the community, Environmental/ Resource Protection, Other	Education, Technical Assistance, State or Federal Legal Changes	4	3
East nampton, NT	narbor Protection Overlay Zone	Law	Law - Land Use	Prevention	Impiemented	NO	Mandatory	Zero	None	Response to Constituent Concerns, Elected officials advocated, To protect the community, To reduce development pressure, Environmental/ Resource Protection	Education		5
East Hampton, NY	Setbacks from Bluffs and Wetlands	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Zero	None	Response to Constituent Concerns, To protect the community, Environmental/ Resource Protection	Education	5	4
East Hampton, NY	Local Waterfront Revitalization Plan Incorporates Climate Change and Policy of Strategic Retreat	Plan	Plan - Other	Procedural	Implemented	No	Mandatory	Medium (< \$100,000)	State	To protect the community, Environmental/Resource Protection, Other	Funding, Technical Assistance, State or Federal Legal Changes	4	5
Greenwich, CT	Flood Venting Requirements	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Low (< \$10,000)	None	To protect the community	Education, Technical Assistance	4	5
Greenwich, CT	Freeboard - 1 Ft in A/AE 2 Ft in VZ	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Low (< \$10,000)	None	To protect the community	Education, Technical Assistance	5	5
Greenwich, CT	Green Area Ordinance	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Medium (< \$100,000)	None	To protect the community, Environmental/Resource Protection	Other	3	5
Greenwich, CT	Comprehensive Plan Incorporates Climate Change	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	None	To protect the community	Education, Technical Assistance	4	5
Greenwich, CT	Evacuation Mapping	Education/ Outreach		Procedural	Implemented	Yes	Implemented	Low (< \$10.000)	None	To protect the community	Education, Technical Assistance, Other	4	5
Greenwich, CT	Flood Zone Home Elevation Database	Policy		Procedural	Implemented	Yes	Advisory	Medium (< \$100,000)	NOAA	To protect the community	Education, Technical Assistance, Funding	4	5
Greenwich, NJ	Conservation Zone - Restrictive Zoning and Environmental Impact Statement Requirement	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Low (< \$10,000)	None	To protect the community, Environmental/Resource Protection	Other	0	5
Greenwich, NJ	Coastal Community Vulnerability Assessment Tool	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Very Low (< \$1,000)	State, NOAA	Other	Education	2	5
Groton, CT	Public Works/Infrastructure Decision Guidance incorporates Climate Change	Policy	Gray Infrastructure	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	None	To protect the community	Funding	3	3
Groton, CT	Coastal Climate Change Project	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Very Low (< \$1,000)	Other	To protect the community	Other	2	4
Guilford, CT	Comprehensive Plan Incorporates Climate Change	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	Other	Response to Constituent Concerns, Environmental/Resource Protection	Funding	3	3
Guilford, CT	Hazard Mitigation Plan Incorporates Climate Change	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	Zero	FEMA	To protect the community	Other	4	4
Guilford, CT	Community Coastal Resiliency Plan	Study/Pilot Project	Plan - Other	Procedural	Completed	Yes	Advisory	Medium (< \$100,000)	NOAA	To protect the community	Education, Funding	4	4
Guilford, CT	Formal resolution recognizing climate change	Policy		Procedural	Completed	Yes	Advisory	Zero	None	To protect the community	State or Federal Legal Changes, Funding	3	4
Hampton, NH	Wetlands Conservation District Zoning	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Medium (< \$100,000)	State	Response to Constituent Concerns, Environmental/Resource Protection, To protect the community, To reduce development pressure	Funding	2	5
Hampton, NH	Comprehensive Plan Incorporates Climate	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Medium (<	None	To protect the community, Environmental/Basource Protection	Other	2	5
Hampton, NH	Coastal Adaptation Workgroup Participant	Study/Pilot Project		Procedural	Implemented	Yes	Advisory	Zero	None	Environmental/Resource Protection, Other	Education	3	5
Hampton, VA	Freeboard - 1 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	Very Low (<	None	To earn CRS credits	State or Federal Legal Changes,	5	5
Hampton, VA	City Flood Protection Law	Law	Law - Land Use	Accommodati	Implemented	No	Mandatory	Very Low (<	None	To earn CRS credits	Technical Assistance	5	5
Hampton, VA	Comprehensive Waterways Management Plan	Plan	Plan - Other	Procedural	Completed	Yes	Advisory	High (<	None	Response to Constituent Concerns	Education	4	3
Hampton, VA	Beachfront and Storm Protection Management	Plan	Plan - Other	Protection	Implemented	No	Advisory	Medium (< \$100,000)	None	To protect the community	Funding	5	5
Hampton, VA	Tidal Floodplain Study and Protection Plan	Study/Pilot	Plan - Other	Protection	Completed	Yes	Advisory	Medium (<	None	To protect the community	Funding	5	5
Hampton, VA	Appointing Waterways Grants Manager	Administrative		Procedural	Implemented	No	Implemented	Medium (< \$100,000)	None	Response to Constituent Concerns	Technical Assistance	5	5

Municipality/ County	Adaptation	Practice Type	Subtype	Strategy	Phase	Incorpor ation of CC	Enforc. Strength	Costs	Funding Source	Motivations	Improve Effectiveness	Effectiv	Replic
Hull, MA	Freeboard Incentive Program	Policy	Building Code	Accommodati	Implemented	No	Incentive	Low (<	None		Education	4	4
Hull, MA	Capital Investment in Culverts and Tidegates	Capital	Green Infrastructure	Protection	Implemented	No	Implemented	High (<	State	Environmental/Resource Protection		4	3
Hull, MA	Overlay Zone incorporates Climate Change	Law	Law - Land Use	Accommodati on	Implemented	Yes	Permissive	\$1,000,000) Low (< \$10,000)	Other	Funding was available, To protect the community, Response to Constituent Concerns	Education, Funding, Technical Assistance	4	3
Hull, MA	Code Requirement that Planning Board Consider	Law	Law - Land Use	Procedural	Implemented	Yes	Mandatory	Zero	Other	To protect the community, Response	Education, Funding, Technical	4	4
Hull, MA	Height Limit Waivers	Law	Law - Land Use	Accommodati	Implemented	No	Permissive	Zero	None	To protect the community	Education	4	4
Hull, MA	Hazard Mitigation Plan Incorporates Climate	Plan	Plan - HMP	on Procedural	Completed	Yes	Advisory	Zero	FEMA	To protect the community	NA	4	5
LL.II MA	Change Reach Management Plan Incomposition Climate	Plan	Plan - Other	Procedural	Implemented	Vas	Achinony	Low (c	None	To protect the community	Education Technical Assistance	4	6
1	Change	1	Level and the	A	lastantat	No	Mandatan	\$10,000)	0.5	Deserve la Constituent Constant	State or Federal Legal Changes		0
LUWUS, DE	Produptian Ordinatics - Frazie dots waterials Prohibited and Dune Protection	Law	Law - Land Ose	on	mpamentad	NO	Mandatory	2410	Guilar	Elected officials advocated, To protect the community, To reduce development pressure, Environmental/ Resource Protection	Education, Puncing		3
Lewes, DE	Higher Height Limits in Flood Zone	Law	Law - Land Use	Accommodati on	Implemented	No	Permissive	Zero	Other	Response to Constituent Concerns, Elected officials advocated, To protect the community, Environmental/ Resource Protection, To earn CRS credits	Education, Funding	4	3
Lewes, DE	Climate Change and Hazard Mitigation Plan	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	FEMA	Response to Constituent Concerns, Elected officials advocated, To protect the community, To earn CRS credits, Environmental/Resource Protection, Funding was available	Education, Funding	4	3
Lewes, DE	Establishment of Mitigation Planning Team	Administrative		Procedural	In Progress	Yes	Implemented	Low (< \$10,000)	FEMA	Response to Constituent Concerns, Elected officials advocated, To protect the community, To earn CRS credits, Environmental/Resource Protection	Education, Funding	5	3
Little Silver, NJ	Open Space Levy, Approved Open Space Plan and Wetlands Mitigation Bank	Law	Law - Fiscal	Prevention	Implemented	No	Implemented	NA	NA	NA	NA	NA	NA
Little Silver, NJ	Coastal Wetlands Ordinance	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	NA	NA	NA	NA	NA	NA
Little Silver, NJ	Flood gauge warning system	Capital Investment		Procedural	Implemented	No	Implemented	Low (< \$10,000)	State Police, FEMA, Other Towns	Funding was available	NA	NA	NA
Little Silver, NJ	Coastal Community Vulnerability Assessment Tool	Study/Pilot Project		Procedural	Completed	Yes	Advisory	NA	NA	Other	NA	NA	NA
Marshfield, MA	Comprehensive Plan Incorporates Climate Change	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Mandatory	Very Low (< \$1,000)		To protect the community, Environmental/Resource Protection	Funding, Education	4	4
Marshfield, MA	South Shore Coastal Hazards Adaptation Plan	Study/Pilot Project	Plan - Other	Procedural	Completed	Yes	Advisory	Medium («c \$100,000)		Funding was available, To protect the community, Environmental/Resource Protection	Education	3	5
Marshfield, MA	Coastal Advisory Committee	Administrative		Procedural	In Progress	Yes	Implemented	Very Low (< \$1,000)		To protect the community, Environmental/Resource Protection	Funding, Education	NA	5
New Castle County, DE	Freeboard - 1.5 Ft	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Very Low (< \$1,000)		To protect the community	Education, Technical Assistance	4	4
New Castle County, DE	Hazardous Materials Prohibited in Floodplain	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Low (< \$10.000)		To protect the community	Technical Assistance, Funding	2	5
New Castle County, DE	Floodplain Setbacks / Prohibits new subdivisions	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Very Low (<		To protect the community	Education, Technical Assistance	4	5
New Castle County, DE	FEMA Cooperative Mapping Project	Administrative		Procedural	Completed	No	Implemented	Very Low (<	FEMA	Funding was available, To protect the	Funding, Technical Assistance	4	5
New Castle, DE	Freeboard - 1 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	\$1,000) Very Low (<	None	community To protect the community	Education	4	5
New Castle, DF	Delaware Coastal Resiliency Action Plan	Study/Pilot	Plan - Other	on Procedural	Completed	Vas	Achisony	\$1,000)	None	To protect the community	Education	3	5
New Castle, DL		Project		riccedural	Completed	100	Powiably .	\$1,000)	TRUTTE	To protect the continuity			
New York, NY	Lone Green - Provisions to allow relocation of utilities to rooftops Local Waterfront Revitalization Plan Incorporates Climate Change and Extends Jurisdictional	Plan	Plan - Other	Accommodati on Procedural	Completed	Yes	Mandatory	High (< \$1,000,000) High (< \$1,000,000)		Environmental/Hesource Protection	Education Education, State or Federal Legal Changes	3	5
Naw York NV	Boundary	Plan	Plan Other	Propadural	Completed	Vas	Achiconi	High / c		Environmental/Percurse Protection	Other	2	2
		r iait	rian - Oniei	Procedural	Completed	105	Auvisory	\$1,000,000)					
New York, NY	Coastal Strategies for Climate Resilence/Urban Waterfront Adaptive Strategies Project (Dept of City Planning)	Study/Pilot Project		Procedural	In Progress	Yes	Advisory	High (< \$1,000,000)		Response to Constituent Concerns, Environmental/Resource Protection	Education	4	4
New TOPK, NT	NTC Panel on Climate Change and Report	Project		Procedural	in Progress	Tes	Advisory	\$1,000,000		to protect the community	Punding	*	3
Norfolk City, VA	Freeboard - 1 Ft and Flood Protection Ordinance	Law	Building Code	Accommodati	Implemented	No	Mandatory	Zero	None	To earn CRS credits, Response to Constituent Concerns To protect the community, Elected officials advocated	Other	3	5
Nortolk City, VA	Stormwater Upgrades	Investment	Gray Infrastructure	on	Implemented	NO	Implemented	(\$>1,000,001)	None	Elected officials advocated, To protect the community	Funding	2	3
Norfolk City, VA	Comprehensive Plan Incorporates Sea Level Rise	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Very High (\$>1,000,001)	None	Response to Constituent Concerns, Elected officials advocated, To protect the community, Environmental/ Resource Protection	Funding, Education	4	4
Norfolk City, VA	Coastal Flood Study	Study/Pilot Project		Procedural	Completed	Yes	Advisory	High (< \$1,000,000)	Other	Response to Constituent Concerns, Elected officials advocated, To protect the community	Funding	2	5
North Kingstown, RI	Assessment of Coastal Wetland Vulnerability	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Low (< \$10,000)	NOAA	Funding was available, To earn CRS credits, Response to Constituent Concerns, To protect the community, Environmental/Resource Protection	Education, State or Federal Legal Changes, Technical Assistance	3	4
North Kingstown, RI	Climate Change Vulnerability Analysis	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Medium (< \$100,000)	NOAA	All	Education, Funding, State or Federal Legal Changes, Technical Assistance	4	4
North Kingstown, RI	Sea Level Rise Pilot Study and Plan	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Medium (< \$100,000)	State	All except elected officials advocated	Education, State or Federal Legal Changes	5	4
Ocean City, MD	Freeboard - 5 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	NA	Other	NA	NA	4	1
Ocean City, MD	Transfer of Development Rights Program	Law	Building Code	Retreat	Implemented	No	Mandatory	NA	Other	NA	NA Technical Assistances	4	4
Oceanport, NJ	Freeboard - 2 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	Very Low (<	None	To earn CRS credits, To protect the	Education	5	5
Oceanport, NJ	Flood Gauge Warning System	Capital Investment		on Procedural	Implemented	No	Implemented	\$1,000) Low (< \$10,000)	State Police, FEMA, Other	community Funding was available	Funding	4	2
Oceanport, NJ	Coastal Community Vulnerability Assessment	Study/Pilot		Procedural	Completed	Yes	Advisory	Zero	rowns	To protect the community	Funding	3	4
Ogunquit, ME	Tool Redefined Mean High Water to increase margin over current observations by 4 feet	Project Law	Law - Land Use	Procedural	Implemented	Yes	Mandatory	Zero		Response to Constituent Concerns, To protect the community, Environmental/	Education, State or Federal Legal Changes, Technical Assistance	4	5
Ogunquit, ME	Comprehensive Plan - Incorporates Climate Change	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Zero		Response to Constituent Concerns, Elected officials advocated, To protect the community, Environmental/	Education, Technical Assistance	4	5
Ogunquit, ME	Sea Level Rise Study (Sewer District)	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Low (< \$10,000)	Other	Hesource Protection Funding was available, Elected officials advocated, Environmental/ Resource Protection	State or Federal Legal Changes, Funding, Technical Assistance	3	4

Municipality/ County	Adaptation	Practice Type	Subtype	Strategy	Phase	Incorpor ation of CC	Enforc. Strength	Costs	Funding	Motivations	Improve Effectiveness	Effectiv	Replic ability
Ogunquit, ME	Redefined Mean High Water to increase margin	Law	Law - Land Use	Procedural	Implemented	Yes	Mandatory	Zero		Response to Constituent Concerns, To	Education, State or Federal Legal	4	5
Ogunquit, ME	Comprehensive Plan - Incorporates Climate Change	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Zero		Resource Protection Resource Protection Response to Constituent Concerns, Elected officials advocated, To protect the community, Environmental/	Education, Technical Assistance	4	5
Ogunquit, ME	Sea Level Rise Study (Sewer District)	Study/Pilot Project		Procedural	Completed	Yes	Advisory	Low (< \$10,000)	Other	Funding was available, Elected officials advocated, Environmental/	State or Federal Legal Changes, Funding, Technical Assistance	3	4
Poquoson, VA	Freeboard - 1 Ft	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Low (< \$10,000)	None	To earn CRS credits, To protect the community	Other	4	5
Poquoson, VA	Pump Station Improvements	Capital Investment	Gray Infrastructure	Accommodati on	Implemented	Yes	Implemented	NA	None	To earn CRS credits, To protect the community, Environmental/Resource Protection	Other	5	3
Poquoson, VA	Flood Management Overlay Ordinance	Law	Law - Land Use	Accommodati on	Implemented	No	Mandatory	Low (< \$10,000)	None	Other	Other	5	5
Poquoson, VA	Comprehensive Plan Incorporates Sea Level Rise	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	None	To protect the community	Education, Technical Assistance	3	3
Poquoson, VA	Hazard Mitigation Plan Incorporates Sea Level Rise	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	Low (< \$10,000)	Other	To earn CRS credits, To protect the community	Funding	3	2
Poquoson, VA Portsmouth, NH	Tidal Wetlands Buffer Protection - 100 Feet	Law	Law - Land Use	Protection	Implemented	No	Mandatory	Low (<	None	To protect the community,	Education	3	4
Portsmouth, NH	Coastal Resiliency Initiative	Study/Pilot		Procedural	In Progress	Yes	Advisory	\$10,000) Low (<	Other	Environmental/Resource Protection To protect the community,	Funding	4	3
Portsmouth, VA	Freeboard - 1.5 Ft	Law	Building Code	Accommodati	Implemented	No	Mandatory	\$10,000) Low (<	None	Environmental/Resource Protection To protect the community, To protect	State or Federal Legal Changes,	5	4
Portsmouth, VA	Elevated bulkhead as part of storefront park	Capital	Grav Infrastructure	on Protection	Implemented	No	Implemented	\$10,000) Low (<	Other	the community To protect the community.	Funding	2	3
Portsmouth VA	reconstruction	Investment	Law - Land Line	Procedural	Implemented	No	Mandaton	\$10,000)	None	Environmental/Resource Protection	State or Federal Legal Charges	4	2
Portainodali, VA		Lun	Lun Card Ost	1 IOCCOURT			interiority	\$10,000)			Funding		
Portsmouth, VA	hazardous materials in floodplain	Law	Law - Land Use	on	Implemented	NO	Mandatory	\$10,000)	Other	to protect the community	Funding	4	•
Portsmouth, VA	Floodplain Management and Repetitive Loss Plan	Plan	Plan - Other	Procedural	Completed	No	Mandatory	Low (< \$10,000)	Other	To protect the community	Funding	4	5
Portsmouth, VA	Public Outreach and Coordination	Education/ Outreach		Procedural	In Progress	No	Implemented	Low (< \$10,000)	Other	To protect the community	Technical Assistance, Funding	4	4
Saco, ME	Freeboard - 3 Ft	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Very Low (< \$1,000)	NOAA	To protect the community	Education	4	5
Saco, ME	Shoreland Zoning Ordinance	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Medium (< \$100,000)	State	To protect the community, Environmental/Resource Protection	Education, Technical Assistance	3	5
Saco, ME	Saco Bay Sea Level Rise Working Group Project	Study/Pilot		Procedural	In Progress	Yes	Advisory	Medium (<	NOAA	Response to Constituent Concerns, Environmental/Resource Protection	Funding	3	5
Scarborough, ME	Open space fund	Capital	Green Infrastructure	Prevention	Implemented	No	Mandatory	NA	Other	Environmental/Resource Protection		NA	4
Scarborough, ME	Cluster Zoning Required in Coastal Zone	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Low (<	None	To protect the community, Emirormental/Resource Protection	Education	3	5
Scarborough, ME	Flood Ordinance Notification Provisions	Law	Law - Land Use	Procedural	Implemented	No	Mandatory	Very Low (<	None	Other	NA	3	5
Scarborough, ME	Growth Management Ordinance/Residential Development Cap	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Very Low (< \$1,000)	None	To protect the community, To reduce development pressure	Education	3	NA
Scarborough, ME	Saco Bay Sea Level Rise Working Group Project	Study/Pilot Project		Procedural	In Progress	Yes	Advisory	Low (< \$10.000)	State	Funding was available, To protect the community	Funding, Technical Assistance	4	4
Sea Isle City, NJ	Strict Enforcement of Flood Ordinance - Issued	Policy	Building Code	Accommodati	Implemented	No	Mandatory	Medium (<		Funding was available, Elected	Education, Funding	4	3
Sea Isle City, NJ	Cumulative substantial improvement ordinance	Law	Law - Land Use	Procedural	Implemented	No	Mandatory	Low (<		Elected officials advocated, To protect	Education, Funding	5	5
Sea Isle City, NJ	Comprehensive Plan Incorporates SLR	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Medium (<	0	Elected officials advocated, To protect	Education, Funding, State Law	4	3
Somerset County, MD	Maryland Coast Smart Rising Sea Level Guidance Study	Study/Pilot Project	1	Procedural	Completed	Yes	Advisory	\$100,000) Very Low (< \$1,000)	NOAA, State	the community Funding was available, To protect the community, Environmental/Resource	State or Federal Legal Changes, Funding	1	5
Southampton, NY	Coastal Erosion Districts	Administrative	Green Infrastructure	Protection	Implemented	No	Implemented	Very Low (< \$1,000)	None	Protection Funding was available, Response to Constituent Concerns, To protect the community, Environmental/Resource Protection	Education, Funding, State or Federal Legal Changes, Technical Assistance	3	4
Southampton, NY	Vegetation Preservation Ordinance	Law	Law - Land Use	Prevention	Implemented	Yes	Mandatory	Medium (< \$100,000)	None	Response to Constituent Concerns, Elected officials advocated, Environmental/Resource Protection, To protect the community	Education	2	4
Southampton, NY	Transfer of Development Rights Program	Law	Law - Land Use	Prevention	Implemented	No	Permissive	Medium (< \$100,000)	None	Response to Constituent Concerns, To protect the community, Environmental/ Resource Protection	Education, Funding	2	4
Southampton, NY	Coastal Erosion Hazard Law	Law	Law - Land Use	Prevention	Implemented	No	Mandatory	Medium (< \$100.000)	None	To protect the community, Environmental/Resource Protection	Education, Funding, Technical Assistance	3	4
Southampton, NY	Community Preservation Fund (2% Real Estate Transfer Tax) for land conservation	Law	Law - Fiscal	Prevention	Implemented	No	Mandatory	Low (< \$10,000)	State	Funding was available, Elected officials advocated, To protect the community, Environmental/Resource Protection, Response to Constituent Concerns	Education, Funding	4	3
Southampton, NY	Comprehensive Plan - Goal to adopt policy of strategic retreat	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	NA	None	Elected officials advocated, Response to Constituent Concerns, Environmental/Resource Protection, To reduce development pressure	Funding, State or Federal Legal Changes, Technical Assistance	3	3
Southold, NY	Freeboard - 2 Ft	Law	Building Code	Accommodati on	Implemented	No	Mandatory	Medium (< \$100,000)	None	To protect the community	Funding, Technical Assistance	3	4
Southold, NY	Transfer of Development Rights	Law	Law - Land Use	Prevention	Implemented	No	Permissive	Very Low (< \$1,000)	None	Other	County Legal Changes	1	3
Southold, NY	Community Preservation Fund (2% Real Estate Transfer Tax) for land conservation	Law	Law - Fiscal	Prevention	Implemented	No	Mandatory	Low (< \$10,000)	None	Response to Constituent Concerns	Funding	4	2
Southold, NY	Comprehensive Plan Incorporates Climate	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Low (<	Other	To protect the community	Education, Funding, State or Federal Legal Changes	0	4
Southold, NY	Local Waterfront Revitalization Plan	Plan	Plan - Other	Procedural	Implemented	No	Mandatory	High (<	State	To protect the community	Education, Funding	3	4
Southold, NY	NOAA Coastal Services Center Roadmap Project	Study/Pilot		Procedural	In Progress	No	Advisory	Low (<	NOAA, NGO	To protect the community	Education, Funding, Technical	2	4
Worcester County, MD	Freeboard - 2 Ft	Project Law	Building Code	Accommodati	Implemented	No	Mandatory	\$10,000) NA	(TNC) NA	NA	Assistance NA	NA	NA
Worcester County, MD	Comprehensive Plan Incorporates Climate	Plan	Plan - Comprehensive	on Procedural	Completed	Yes	Advisory	Zero	NA	Other	Education	3	5
Worcester County, MD	Change Hazard Mitigation Plan Incorporates Sea Level	Plan	Plan - HMP	Procedural	Completed	Yes	Advisory	NA	Other	Other	Education	NA	3
Worcester County, MD	Preservation of Assateague Island	Capital		Retreat	Implemented	No	Implemented	NA	Other	Other	Other	5	1
Worcester County, MD	Worcester County Sea Level Rise Response	Study/Pilot		Procedural	Completed	Yes	Advisory	Zero	NA	Funding was available	Education	3	NA
York, ME	Strategy Flood Hazard Development Permits Apply to	Project	Building Code	Accommodati	Implemented	No	Mandatory	Zero	None	Other	State or Federal Legal Changes.	3	4
York. ME	Minor Projects	Law	Building Code	on Accommodati	Implemented	No	Mandatory	Zero	None	To protect the community	Funding Other	4	4
York ME	Transfer of Development Diskin	Law	Law Law	on	Implamente	No	Dermission	Zero	None	Other	Other	1	0
York, ME	Comprehensive Plan Incorporates Climate	Plan	Plan - Comprehensive	Procedural	Completed	Yes	Advisory	Low (<	Other	To protect the community,	Other	5	5

B. Fieldwork protocol

Fieldwork	Interview	Instrument
I 'tetawork	Interview	monument

Туре	Question
General	We know that climate change and its associated impacts - rising sea levels, increased severe storms, and flooding have been identified as an emerging problem for many coastal communities.; Is this something that seems to be relevant in your community? Is this something that you see the elected officials of this community concerned about? Is it something your community members are concerned about?
Policy and	Is this something that seems to be relevant in your community? Is this
Programs	something that you see the elected officials of this community concerned about? Is it something your community members are concerned about? One of the goals of this project is to identify and measure best practices in each community. We are specifically looking for a low-cost practice that supersedes state and/or federal requirements (FEMA/Coastal Management, etc.)
Motivations	Direct - Have you adopted any regulations as a direct result of concerns about CC and SLR?
	Incidental - Have you adopted any of these or any other regulations or code changes incidental to CC or SLR (e.g. because of concerns about flooding) that have the effect of adapting to CC and SLR?
Plans	Has the town/city drafted a climate change plan?
	Do you have a local hazard mitigation plan?
	A. When was it last updated? B. If was had so on SIP been incorporated into it?
Coastal Zone	Do you have coastal zone setback requirements which exceed state law?
Sethack	How does the setback exceed state law?
Wetland Setback	Do your coastal wetland regulations meet or exceeded state law?
Comprehensive Plan	Do you have an adopted comprehensive plan? If yes, has cc or SLR been incorporated into it?
FEMA/Flood	A) Does the county participate in the CRS?
Hazard Management	B) Does the county meet or exceed FEMA flood elevation requirements?Do you have a freeboard requirement? In what zone does this apply?C) Is your zoning and/or comprehensive plan integrated with FEMA flood hazard zone maps?
Shoreline	D) What percentage of the county is in the 100 year floodplain? Do you have municipal regulations controlling shoreline hardening that
Climate Change	are different from or go beyond state code? Have you considered or do you include climate change projections in any aspects of town governance?
Projections	aspects of town governance.
Specific	Coastal Flood Management
Adaptations	-What is your town doing to mitigate coastal flood hazard risk and related hazards/risks (e.g. erosion, wetland loss, and potential sea level rise)?
	-What coastal hazard management programs, projects, or other activities would you highlight as best practices, from which other towns could learn?

Specific Programs or Activities – background and cost effectiveness Getting the story behind a best practice

What's the name of the project/practice?

Why do you think it's a best practice? Do you think it would work in another town? Why would you recommend another town do something similar?

How did this project get started in this town? Why here as opposed to another town?

Who were the key players involved with initiating this project and who led the effort?

Who benefits and who pays? Are there multiple towns involved? Who else should I talk to get project specifics?

Project Cost

How much did the project cost initially (dollar amount)? How did the project cost compare to the original estimated cost?

Who funded the project?

How much does this project cost to maintain annually (dollar amount)? Do you consider the project to be low cost? Why or why not?

3.3. Program Effectiveness

3.3.1. What are the goals of the project? What does it intend to accomplish?

3.3.2. Do you think this program is effective? How might it be changed? Will it be effective in the future? Why or why not?

3.3.3. Can you give examples of specific behavioral, structural, legal, or other institutional adjustments (e.g. zoning) that have resulted from this program?

3.3.4. In what ways is the program low cost compared to observed benefits? In what ways is it expensive?

3.3.5. What should have been done differently for more effectiveness or to save money?

3.3.6. What other lessons have been learned implementing the program or project? What would you recommend to a neighboring community if they were to adopt the best practice?

4. Specific Programs or Activities - best practice assessment

4.1. Environmental Effects and Risk-based Management

4.1.1. Does the project/program include assumptions of a changing climate in any respect? Yes/no.

4.1.2. If yes, how specifically does the project/program account for the possibility of a changing climate?

4.2. Monitoring Program Effectiveness

4.2.1. Is monitoring for effectiveness built into the project or program design?

4.2.2. If yes, what do you use as a baseline and what metrics do you use to measure effectiveness?

5. Repackaging and Best Practice Transferability

5.1. Constraints and Limitations to Consider

5.1.1. What constrains and/or limits implementing the program/project? How were/are these challenges overcome?

5.1.2. What are the principal constraints or limitations that you think would prevent a neighboring community from adopting the best practice?6. Next Steps

6.1. Best Practice Next Steps

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- 6.1.1. Where does the project go from here? What are the future plans?
- 6.2. Following Up
- 6.2.1. May we follow up if have additional questions?
- 6.2.2. Who else should we talk to about this project?