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DEATH, TAXES, AND CLIMATE INDUCED FLOODING:
HOW LOCAL GOVERNMENTS CAN USE TAX POLICY TO IMPLEMENT
CLIMATE ADAPTATION PROJECTS

by

Jacob Selgestad

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ABSTRACT

Death, Taxes, and Climate Induced Flooding:
How Local Governments Can Use Tax Policy to Implement Climate Adaptation Projects

Jacob Selgestad

Director: Shane Nordyke, Ph.D.

As the effects of climate change intensify, major flooding events will become commonplace throughout the United States. This will make climate adaptation actions a necessity for many communities. This paper aims to provide useful information for state and local policymakers hoping to better understand the nature, importance, and implementation of climate adaptation actions. This paper includes analysis regarding: the links between climate change and flooding, the locations most susceptible to flooding in the US, the potential impacts of flooding, the role of state and local governments, potential climate adaptation actions, and how tax policy can be used to help implement policies aimed at climate adaptation. While the early sections of the paper hope to provide background and context, the latter sections concerning solutions and how to use tax policy to implement them are aimed at helping policymakers make informed decisions about what type of adaptation action and implementation method is best for their community. This paper does not set out to recommend one specific best course of action, because community needs vary. Rather, this paper should be viewed as a tool that can be used to provide context and assistance for policymakers interested in understanding and implementing climate adaptation projects.

KEYWORDS: Climate Change, Adaptation, Taxes, Flooding, Local Government

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Introduction

As the impacts of climate change intensify, people are going to have to fundamentally change the way they live their lives. Much attention is currently directed towards partisan political debates centered on the role of humans in climate change. While national politicians try to score political points arguing about the causes of climate change, state and local governments are going to have to actually deal with the impacts of global climate change. One of the major impacts of climate change in the United States is going to be increases in both the frequency and severity of flooding. With two major oceanic coasts and an extensive network of rivers, the threat of both coastal and inland flooding is pervasive throughout the United States. This paper will discuss how climate change causes flooding, identify the locations in the United States that are most susceptible to flooding, examine how the anticipated increases in climate induced flooding may impact cities in the United States, discuss the role state and local governments play in combatting those threats, evaluate some potential adaptation actions, and explain how these governments can use tax policy to help implement those adaptation actions.

When analyzing what actions the government should take to combat climate change, it is necessary to identify the type of action being taken, the level of government taking the action, and the policy tool they use to take the action. Actions to combat climate change are divided primarily into “mitigation” and “adaptation” actions.¹ Mitigation actions are aimed at combatting the root causes of climate change, like

¹ University Corporation of Atmospheric Research. "Climate Mitigation and Adaptation." 2011. <https://scied.ucar.edu/longcontent/climate-mitigation-and-adaptation>.

greenhouse gas emissions, while adaptation actions are focused primarily on reducing the vulnerability of areas that could be impacted by climate change.² Climate change is an issue that requires action by all levels of government, from city governments to the federal government. As such, when analyzing climate change policy it is important to make clear what level of government is serving as the actor. Additionally, it is important to identify the policy tool being used by whatever government entity is the actor. Governments have a variety of different policy tools they can use, including a number of different types of regulations and incentive programs.

Currently, much of the literature on the government's role in combatting climate change is focused on mitigation actions taken by the federal government. While this is important, there is substantially less research surrounding adaptation strategies and the role of local government entities. The unique contribution of this paper is that it frames climate change as a local issue that requires adaptation measures, establishing a new framework for understanding the issue and outlining potential courses of action. It is important to develop an understanding about climate adaptation actions and how local governments can implement them. Regardless of its causes, climate change is happening, and local and state governments are going to have to deal with its associated impacts. This paper hopes to help build an understanding of how that can actually be done.

Climate Change and Flooding

It is important to understand the specific ways climate change causes flooding before trying to look at how the harms associated with the flooding can be combatted.

² Ibid.

There is widespread agreement human activities have been the primary driver of climate change.³ However, this question draws attention away from the fact that no matter what the cause of climate change is, it is actively happening and people are going to have to adapt, regardless of cause. There is strong evidence that the Earth is rapidly warming. For example, the climate on Earth is changing faster now than at any point in the history of modern civilization.⁴ This is evidenced by the fact that nine of the ten hottest years on record are between 2005 and 2018.⁵ Since the beginning of the 20th century, annual average temperatures have increase by 1.8°F across the contiguous United States.⁶ This heating makes the ocean undergo thermal expansion and causes “land-based ice masses”, like glaciers, to melt.⁷ This causes sea levels to rise, as the ocean is expanding from the heat and melting ice is entering the already expanding ocean. Globally, average sea level has risen approximately 8 inches since 1900.⁸ In that same time, the median sea level along the coast in the United States has increased 9 inches, putting them in a slightly worse position than the average country.⁹ Evidence of sea level rise includes the fact that

³ Reidmiller, David, Christopher Avery, David R. Easterling, Kenneth E. Kunkel, Kristin Lewis, Thomas Maycock, and Brooke Stewart. "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II." 2018.

https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf, 34

⁴ Ibid., 34

⁵ Leslie, John, and Brady Phillips. "2018 Was 4th Hottest Year on Record for the Globe: The U.S. Experienced 14 Billion-dollar Weather and Climate Disasters." February 6, 2019.

<https://www.noaa.gov/news/2018-was-4th-hottest-year-on-record-for-globe>.

⁶ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 39

⁷ Ibid., 43

⁸ Leong, Jo-Ann, and John J. Marra. "National Climate Assessment 2014: Hawai'i and Pacific Islands." 2014. <https://nca2014.globalchange.gov/report/regions/hawaii-and-pacific-islands>.

⁹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 39

minor coastal flooding in the United States “occurred just once every one to five years in the 1950s”, but by 2012 it was occurring about once every three months.¹⁰

In addition to rising sea levels, climate change is expected to contribute to flooding through an increase in “heavy precipitation events.”¹¹ There are already some signs of increases in heavy precipitation events, like the fact that over the last 100 years, a larger percentage of total annual rainfall has come from large, single-day precipitation events.¹² In some instances rising seas may compound the harms associated with these coastal storms and high precipitation events.¹³ Part of the reason for this is that higher sea levels will allow storm surges to travel farther inland than in the past.¹⁴ In addition to large storms, rising sea levels are expected to make “nuisance” or “recurrent” tidal flooding more frequent.^{15 16}

Further, some areas of the coastal United States are expected to be permanently inundated, or submerged under water, by 2100 as a result of sea level rise.^{17 18} Most simulations that test potential sea level rise scenarios show that retreat and abandonment

¹⁰ Dahl, Kristina A., Erika Spanger-Siegfried, Astrid Caldas, and Shana Udvardy. "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise." *Elem Sci Anth*5 (March 25, 2017): 37. doi:<http://doi.org/10.1525/elementa.234>.

¹¹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 30

¹² Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 39

¹³ States at Risk. "States at Risk National Summary." States at Risk. "States at Risk National Summary." States at Risk. "States at Risk National Summary.", 1

¹⁴ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 49

¹⁵ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

¹⁶ Hummel, Michelle A., Matthew S. Berry, and Mark T. Stacey. "Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts." *Earth's Future*6 (2018): 622-33. doi:10.1002/2017EF000805., 622

¹⁷ *Ibid.*, 622

¹⁸ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

will likely become necessary to some extent along the coast because of inundation.¹⁹ In the worst case scenarios, between 489 to 668 communities could be inundated by 2100.²⁰ Even if the sea level rise targets set in the Paris Climate Agreement are met, nearly 300 communities still face the threat of inundation.²¹ Areas that face potential inundation could possibly experience decades of life-altering coastal flooding before the area becomes completely unlivable.²²

Taking proper steps to combat climate change, through both mitigation and adaptation actions, has the potential to substantially reduce the negative impacts of sea level rise.²³ However, without proper adaptation actions, more than 20 million US residents could face substantial harms caused by rising sea levels by 2100.²⁴ While taking action to try and mitigate the harms of climate change is important, the importance of adaptation actions becomes clear when one can understand that a certain degree of climate change is already locked in, no matter how well its root causes are addressed. Global sea level takes a long time to respond to changes in the atmosphere, and as such, a certain amount of change in the sea level is already locked in because of the actions of past generations.²⁵ ²⁶ Some models suggest that even if greenhouse gas emissions were

¹⁹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 64

²⁰ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

²¹ Ibid.

²² Ibid.

²³ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 34

²⁴ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

²⁵ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 42

²⁶ Grannis, Jessica. Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use. Report. Georgetown Law, Georgetown. October 2011, 5

completely and immediately stopped, the planet is still likely to experience another 1.8°F of warming by 2050 because of historical emissions.²⁷ Adaptation actions are going to be necessary, because even if mitigation efforts were 100% effective, there would still be lasting effects for communities to deal with.

Locations Susceptible to Flooding

With an understanding of the interactions between climate change and flooding established, it is possible to look at what areas of the US face the biggest flooding threat. The Federal Emergency Management Agency (FEMA) uses floodplains to determine if an area faces flood risk. They primarily define areas as being in a “one-hundred year” or “five-hundred year” floodplain.²⁸ A one-hundred year floodplain means the area can expect to get a major flood once every one-hundred years and a five-hundred year floodplain means the area can expect a major flood once every five-hundred years. Even though an area in a one-hundred year floodplain only has a 1% chance of a major flood occurring in any given year, FEMA still defines these areas as “High Risk.”²⁹ However, it becomes apparent why they do this when one looks at how that probability actually works out for a homeowner. While the probability of a flood happening in any given year is just 1% in a one-hundred year floodplain, someone living in the floodplain with a 30 year mortgage has a 26% chance of experiencing a major flood before their mortgage is paid off.³⁰ This shows how the low probability of a major flood can add up over the years. Additionally, it is worth noting the probabilities for the floods are based over periods of

²⁷ United States. Congressional Research Service. Climate Change: Conceptual Approaches and Policy Tools. By Jane A. Leggett. August 29, 2011. <https://fas.org/sgp/crs/misc/R41973.pdf>, 25

²⁸ FEMA Map Service Center. "Definitions of FEMA Flood Zone Designations." https://efotg.sc.egov.usda.gov/references/public/NM/FEMA_FLD_HAZ_guide.pdf.

²⁹ Ibid.

³⁰ <https://pubs.usgs.gov/gip/106/pdf/100-year-flood-handout-042610.pdf>

hundreds of thousands of years. This means that it is entirely possible for an area to be in a one-hundred year floodplain and be hit with several hundred year floods. They could go hundreds of years without additional floods in the long-run and still average to a 1% chance in any given year.

There are a number of states that have a significant amount of people threatened by climate induced flooding increases. When looking at the total number of people who live in the FEMA one-hundred year floodplain (non-coastal), Florida leads the way with 1.5 million, followed by California and Georgia who have 1.3 million and 570,000 respectively living in the one-hundred year floodplain.³¹ Florida also leads the way when looking at both number of people living in the one-hundred year coastal floodplain , both in terms of total numbers and the proportion of the state’s population.³² Total numbers show that the states with the most people threatened by coastal floods are Florida with 3.5 million, followed by Louisiana and New York who have 950,000 and 430,000 respectively threatened.³³ When looking at proportion of population threatened Florida and Louisiana lead the way again, with 21% and 18% respectively exposed. Following behind them is South Carolina who have 5% of their respective population exposed.³⁴

TABLE 1: Summary of Flooding Threat Faced by States					
Inland (Total)		Coastal (Total)		Coastal (Proportion)	
Florida	1,500,000	Florida	3,500,000	Florida	21%
California	1,300,000	Louisiana	950,000	Louisiana	18%
Georgia	570,000	New York	430,000	South Carolina	5%

³¹ States at Risk. "States at Risk National Summary.", 11-12

³² Ibid., 14

³³ Ibid., 14

³⁴ Ibid., 14

As sea levels rise, Florida and Louisiana are anticipated to face the biggest risk, evidenced by the fact that they are expected to respectively have 4.6 million and 1.2 million people living in the one-hundred year coastal floodplain by 2050.³⁵ While these two states face the biggest threat, the threat is not limited to just them. By the end of the century many coastal cities throughout the Southeast are expected to experience daily flooding from high tides.³⁶ Cities such as Annapolis (Maryland), Norfolk (Virginia), and Miami Beach (Florida) have already been forced to invest in measures to combat flooding that frequently accompanies high tides.³⁷

While the southeast US faces the most risk, other areas of the US will be forced to deal with the consequences of rising sea levels as well. For example, 60% of California's shoreline is bordered by manmade structures, which means that as sea levels rise, much of the California coast will be unable to move further inland to cope.³⁸ Further, Hawaii is expected to see disproportionate increases in sea level because of the way the Earth distributes water unevenly throughout the ocean.³⁹ Additionally, the northeastern US is expected to see increases in heavy rainfall, storm surges, and high tide flooding.⁴⁰ These increases in precipitation have already been noted in the northeastern US, and are only expected to get worse.⁴¹ In the Midwest, increases in precipitation have the potential to

³⁵ Ibid., 3

³⁶ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 47-49

³⁷ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

³⁸ University of California Santa Barbara. "Explore Beaches: Sea Level Rise." 2019.

<http://explorebeaches.msi.ucsb.edu/climate-change/sea-level-rise>.

³⁹ Willis, Joshua K., Andrew Kemp, and Benjamin H. Strauss. "Sea Level Rise." April 2018.

<https://ocean.si.edu/through-time/ancient-seas/sea-level-rise>.

⁴⁰ NCA 2018 (p. 30)

⁴¹ States at Risk. "States at Risk National Summary.", 1

lead to catastrophic flooding. In 2019 the Midwest was hit with major flooding that was caused in large part by increased precipitation in the summer and fall seasons that absorbed into the soil and froze during the winter, making the ground hard and impermeable.⁴² When winter came, the increased precipitation translated into heavy snowfall that gathered into snowpack.⁴³ As weather rapidly warmed throughout the Midwest in mid-March, the large snowpack began to melt, but because the ground takes longer to thaw than the snow, it was still largely impermeable to the melting snow.⁴⁴ As a result,, the melting snow caused massive flooding throughout the Midwest, showing that just because a state is not by the coast, does not mean it is protected from climate induced flooding. Finally, if one looks at the issue of climate induced flooding from a global perspective, they can see just how threatened some areas are. The United States has some of the major port cities that are most exposed to coastal flooding. Miami, New York, New Orleans, and Virginia Beach all rank among the top twenty most exposed major port cities in the world, placing 1st, 3rd, 12th, and 19th respectively.⁴⁵

Moving forward, these areas are going to have to take major steps to prepare for the anticipated climate induced increase in flooding. This is especially true when one looks to the fact that population growth is expected to be concentrated in areas that are

⁴² Harrington, Samantha. "Did Climate Change Cause the Flooding in the Midwest and Plains?" Yale Climate Connections. April 4, 2019. <https://www.yaleclimateconnections.org/2019/04/did-climate-change-cause-midwest-flooding/>

⁴³ Ibid.

⁴⁴ Ibid.

⁴⁵ Nichols, RJ, S. Hanson, C. Herweijer, N. Patmore, S. Hallegatte, Jan Corfee-Morlt, Jean Chateau, and R. Muir-Wood. "Ranking of the World's Cities Most Exposed To Coastal Flooding Today and in the Future." 2007. <https://climate-adapt.eea.europa.eu/metadata/publications/ranking-of-the-worlds-cities-to-coastal-flooding/11240357>, 5

exposed to these harms.⁴⁶ California, Delaware, Maryland, Massachusetts, and Louisiana are the states thought to be most prepared to deal with sea level rise, as they have incorporated considerations for sea level rise and coastal resilience into a number of projects that are believed to be effectively preparing these states for the challenges climate change promises to bring.⁴⁷ Notably absent from this list is Florida, the state that faces the greatest flooding risk by a substantial margin. Despite the incredible threat they face, Florida has only engaged in a relatively average amount of preparedness initiatives.⁴⁸ Florida needs to acknowledge that they face a disproportionate threat relative to other states and will therefore need to invest a disproportionate amount into initiatives that prepare them for the challenges climate change will bring. States have varying threat levels and varying levels of preparedness as climate change threatens to increase the frequency of flooding throughout the US.

Before moving on it is important to make a quick acknowledgement about some possible deficiencies in the FEMA one-hundred year floodplain classification system. This system is currently central to how flood threats are conceptualized, so if there are errors in it, they need to be brought to attention. Some researchers claim that the current FEMA floodplain classification system is oversimplified and uses outdated data.⁴⁹ These researchers updated the FEMA floodplain model with more recent data and included

⁴⁶ Biagini, Bonizella, Rosina Bierbaum, Missy Stults, Saliha Dobardzic, and Shannon M. McNeeley. "A Typology of Adaptation Actions: A Global Look at Climate Adaptation Actions Financed through the Global Environment Facility." *Global Environmental Change*, 25 (March 2014): 97-108. doi:<https://doi.org/10.1016/j.gloenvcha.2014.01.003>, 97

⁴⁷ States at Risk. "States at Risk National Summary.", 14

⁴⁸ *Ibid.*, 3

⁴⁹ Wing, Oliver EJ, Paul D. Bates, Andrew M. Smith, Christopher C. Sampson, Kris A. Johnson, Joseph Fargione, and Philip Morefield. "Estimates of Present and Future Flood Risk in the Conterminous United States." *Environmental Research Letters*, 13 (February 28, 2018). doi:<https://doi.org/10.1088/1748-9326/aaac65>, 1

consideration for smaller streams that are ignored in the more simple FEMA model.⁵⁰

This updated model predicts that 41 million Americans live in the one-hundred year floodplain, while the FEMA model predicts that only 13 million people live in these areas.⁵¹ If this model were to be updated for improved accuracy, it would have significant implications for US climate adaptation policy moving forward. Most projections about potential flooding use the FEMA model, so if it is incomplete, large areas of the United States may be left unprepared for flooding that could have been predicted with proper modeling.

Impacts of Flooding

Harms stemming from climate induced flooding will fundamentally change the lives of those impacted. Evidence shows that climate change is expected to harm “human health and safety, quality of life, and the rate of economic growth” as well as “infrastructure, ecosystems, and social systems that provide essential benefits to communities.”⁵² For the purposes of this section special attention will be paid to the ways in which climate induced flooding is poised to impact infrastructure, the economy, culture, and disadvantaged populations. Climate induced flooding increases are poised to cause many problems for many different species, but for the purposes of this analysis, not every harm will be included. Rather, I will primarily focus on harms impacting humans that can be reduced through the use of climate adaptation actions.

⁵⁰ Ibid., 1

⁵¹ Ibid., 1

⁵² Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 25

Infrastructure

Climate change is a major threat to the United States' already challenged infrastructure networks. The US has scored well below average in measures of their infrastructure quality, and the threat of increased coastal and inland flooding has the possibility to compound these deficiencies.⁵³ Many different forms of infrastructure in the US, from travel infrastructure to energy and other critical infrastructure, face substantial threats from potential increases in flooding.⁵⁴ High tide flooding and more frequent tropical storms threaten to hamper infrastructure on the coasts while the increased frequency of high precipitation events will make it such that the infrastructure in inland regions of the US is threatened as well.⁵⁵

Roads and other forms of transportation infrastructure face a sizeable threat from potential increases in climate induced flooding. Flooding shortens the life expectancy of roads and often causes damage that demands additional maintenance or requires the road to be rebuilt.⁵⁶ Additionally, flooding has the potential to “disrupt traffic, delay construction activities, and weaken or wash out the soil and culverts that support roads, tunnels, and bridges.”⁵⁷ In the status quo, there are around 60,000 miles of coastal roads in the US that already are threatened by flooding.⁵⁸ One can only expect the number of threatened roads will increase as storm surges move further inland along with sea level

⁵³ American Society of Civil Engineers. "Infrastructure Report Card." 2017.

<https://www.infrastructurereportcard.org/>

⁵⁴ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 25

⁵⁵ Ibid., 30

⁵⁶ EPA. "Climate Impacts on Transportation." https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation_.html. January 19, 2017.

⁵⁷ Ibid.

⁵⁸ Ibid.

rise. Further, it is worth noting that transportation networks and infrastructure in rural areas are especially vulnerable to the negative consequences of flooding.⁵⁹ This vulnerability was demonstrated recently by the flooding that occurred throughout the Midwest in 2019 because of melting snow and impermeable soil.⁶⁰ This flooding made travel impossible in many rural areas. In addition to roads, there is the potential for railways to flood, making it such that trains cannot transport people or freight along rail lines. For example, in 2008 there were major floods in the Midwest that resulted in major “east-west rail lines” being closed for several days.⁶¹ Another example occurred in 2012, when flooding from Hurricane Sandy left millions around New York City without commuter rail or subway services for over a week.⁶² Major waterways throughout the United States are also threatened by flooding. Adding to the fact that flooded rivers cannot be safely navigated, extreme precipitation events often cause silt and debris to build up in waterways, making shipping channels shallower and less accessible.⁶³ Finally, it is worthy of note that flooding does not only threaten ground-based transportation infrastructure. 13 of the 47 largest US airports have at least one runway deemed to be vulnerable to coastal storm surges and inundation.⁶⁴ This shows how even air based travel is not entirely protected from the potential consequences of increases in climate induced flooding.

⁵⁹ EPA. "Climate Change and the Health of Indigenous Populations." May 2016.

https://www.cmu.edu/steinbrenner/EPA_Factsheets/indigenous-health-climate-change.pdf, 3

⁶⁰ Harrington, Samantha. "Did Climate Change Cause the Flooding in the Midwest and Plains?" Yale Climate Connections. April 4, 2019. <https://www.yaleclimateconnections.org/2019/04/did-climate-change-cause-midwest-flooding/>.

⁶¹ EPA. "Climate Impacts on Transportation."

⁶² Ibid.

⁶³ Ibid.

⁶⁴ Ibid.

Energy infrastructure also stands to face major challenges related to increases in climate induced flooding. Similar to transportation infrastructure, energy infrastructure is also aging and deteriorating, which creates concerns moving forward about its ability to persevere through more challenging environmental conditions that it was not made to deal with.⁶⁵ In addition to threatening to damage and compromise the integrity of energy infrastructure, flooding threatens to disrupt major processes involved in the energy production process. For example, many power plants rely on a steady supply of water for cooling procedures, and changes in the availability of water caused by flooding could create challenges on this front.⁶⁶ The Atlantic and Gulf Coasts are believed to have significant amounts of oil, natural gas, and electrical infrastructure threatened by potential flooding.⁶⁷ These problems can have a sort of multiplying effect, because oil and natural gas operations rely on electricity to do their work. When flooding disrupts an oil or natural gas operation, it is usually because they have lost their access to electricity, not because of any physical damage caused to their operation by the flood.⁶⁸

Part of the reason damages to infrastructure are so harmful is because they can compound existing issues and also create cascading impacts. For example, Hurricane Harvey caused significant flooding in the Houston area, which caused power outages to occur, which harmed other critical systems that required electricity, like hospitals and wastewater treatment plants.⁶⁹ This creates the potential for flooding to cause service

⁶⁵ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 27

⁶⁶ Ibid., 27

⁶⁷ Ibid., 49

⁶⁸ EPA. "Climate Impacts on Energy." <https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-energy.html>. January 19, 2017.

⁶⁹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 47

disruptions even for areas that are not actively flooded, expanding the overall harms of the flood.⁷⁰ Wastewater treatment plants are an excellent example of how issues with energy infrastructure can compound issues faced by other forms of critical infrastructure. Wastewater treatment plants are susceptible to flooding because they are optimal to build in low lying areas that allow the water to flow downhill to the plant, rather than be pumped to the plant.⁷¹ Additionally, it was seen during Hurricane Harvey in Houston that their wastewater plant was not only flooded, but lost access to electricity because of other issues with energy infrastructure, compounding the harms of the flood.⁷² Some estimates show that the number of people who could lose wastewater services because of a flood could be five times as high as the number of people directly impacted by the flooding.⁷³ This shows how disruptions to energy infrastructure can have cascading and compounding effects on other critical services. One final thing to keep in mind is that repair and maintenance work after a flood will require electricity as well, and any damages to those distribution networks will hamper a community's ability to respond to the disaster.⁷⁴ This subsection demonstrated the threats flooding poses to transportation and energy infrastructure and showed how issues with these critical infrastructure systems can feed into one another.

⁷⁰ Hummel, et al. "Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts." *Earth's Future*, 6 (2018): 622-33. doi:10.1002/2017EF000805., 622

⁷¹ *Ibid.*, 622

⁷² EPA., "Climate Impacts on Energy."

⁷³ Hummel, et al. "Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts." *Earth's Future*, 6 (2018): 622-33. doi:10.1002/2017EF000805., 622

⁷⁴ EPA., "Climate Impacts on Energy."

Economic Impacts

Projected increases in flooding and inundation also pose a large threat to the economy that spans several industries. One of the industries that will be hit the hardest by rising sea levels is the coastal real estate industry.⁷⁵ Approximately a trillion dollars in national wealth is held in coastal real estate that would be threatened by increases in flooding.⁷⁶ Some property could potentially become permanently inundated because of recurrent flooding. Flooding can have a huge impact on property value, which would negatively impact the economy and the government's tax base.⁷⁷ After major flooding along the North Dakota and Minnesota border in 1997, the average value of a home in the 100-year floodplain in that area decreased by \$1,350.⁷⁸ Property taxes are often a critical source of public funds the government needs to provide things like education. When property decreases in value, the government cannot collect as much tax on that property. This leads to a situation where climate induced flooding can harm local public service provisions by decreasing the funds available to the government entity providing the service. These harms have the potential to be compounded by the fact that current growth patterns persist to develop disproportionately along the coast, often with little regard for climate change and possible future flooding.⁷⁹

⁷⁵ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 30

⁷⁶ Ibid., 47

⁷⁷ Fridgen, Patrick M., and Steven D. Shultz. Agricultural Economics Report. Report no. 417. Department of Agricultural Economics, North Dakota State. May 1999.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.38.4035&rep=rep1&type=pdf>.

⁷⁸ Ibid.

⁷⁹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 47

Local economies and industries that rely on natural resources and favorable climate conditions could suffer from increases in climate induced flooding as well.⁸⁰ For example, popular coastal tourist locations face a tremendous risk from climate change.⁸¹ Oftentimes the value in the tourist activities is that they are near the coast, which makes the industry especially vulnerable. Tropical storms and rising sea levels threaten ecosystems that generate economic value in the form of tourists who come to see nature.⁸² In Hawaii, tourism makes up 26% of the state's economy, and the potential loss of Waikīkī Beach carries a 2 billion dollar price tag.⁸³ This is an extreme example of the devastating effect flooding could have on coastal tourism. Areas that rely on coastal tourism are going to have major challenges to overcome if they want to maintain the industry. However, tourism is not the only natural resource based industry that could suffer from increases in flooding. Projected increases in inland flooding leaves a lot of agricultural land in danger. Extreme flooding events can have a dramatic impact on crop yields, resulting in significant harms for those who rely on the industry for their income.⁸⁴ Perhaps even more sensitive to the projected increases in flooding is the aquaculture industry and fisheries. Flooding is projected to decrease the productivity of some fisheries, especially those along the Gulf of Mexico.⁸⁵ Often communities build their entire identity around these industries, making the fight to protect them even more

⁸⁰ Ibid., 25

⁸¹ Ibid., 31

⁸² Leong, Jo-Ann, and John J. Marra. "National Climate Assessment 2014: Hawai'i and Pacific Islands." 2014. <https://nca2014.globalchange.gov/report/regions/hawaii-and-pacific-islands>.

⁸³ Ibid.

⁸⁴ EPA. "Climate Impacts on Agriculture and Food Supply."

<https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply.html>. January 19, 2017.

⁸⁵ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 31

important. Cascading economic impacts from decreased spending and unemployment threaten to tank entire local economies. While oil production does not require favorable climate conditions in the same way that agriculture or tourism does, it is possible to see that climate change could have a notable impact on the economics associated with oil prices. After Hurricane Harvey, price spikes resulted nationwide because of reduced oil production and refining capacity in the Gulf of Mexico.⁸⁶ Protecting economies that rely on natural resources is going to be one of the major challenges associated with increased flooding from climate change. Without proper adaptation action significant economic harm could be done.

It is important to note how the potential risks to infrastructure and the economy discussed here only threaten to intensify in the future, as development is projected to continue to occur disproportionately on the coasts and areas within the 100-year floodplain.⁸⁷ Earlier some critiques were made of the FEMA system used to define floodplain. If the alternative model used in that research is correct, the impact on infrastructure and the economy could be much more significant. If FEMA floodplain maps are accurate 15.7 million people and 700 billion dollars' worth of GDP are in the 100 year floodplain.⁸⁸ However, if the alternative model is correct, 40.8 million people and 2.9 trillion dollars' worth of GDP would be in the 100 year floodplain. With people already building near the coasts disproportionately, the threat of flooding has the potential to substantially increase. Especially if people develop areas that are not in the

⁸⁶ Ibid., 47

⁸⁷ Wing, et al., "Estimates of Present and Future Flood Risk in the Conterminous United States.", 5

⁸⁸ Ibid., 3

official FEMA floodplain, but that may still be just as threatened as property that is within the floodplain.

It is also worth noting that there is an economic impact associated with disaster response as well. There are substantial costs associated with the provision of emergency services during natural weather events like flooding.⁸⁹ The cost of providing these services has been trending upward and is only projected to continue to increase as climate induced flooding becomes more frequent.^{90 91} While these costs do represent a threat to local governments, the role of FEMA is to try and mitigate some of those costs.⁹² As such, emergency relief is a cost that is largely handled at the federal level. It is still important for local governments to have emergency plans to guarantee they will be able to provide services, but in instances where there is serious flooding FEMA will cover much of the cost. Additionally, local and state governments do not do a good job of tracking natural disaster spending, making it difficult to tell what they are spending money on and where costs are coming from.⁹³ While states may not track this spending well, the federal government does a better job. FEMA spending shows that the number of “billion-dollar disasters” is on the rise, with a significant number of these events being

⁸⁹ Pfürtscheller, Clemens, and Reimund Schwarze. "Estimating the Costs of Emergency Services during Flood Events." 4th International Symposium on Flood Defence, January 2008.

⁹⁰ O'Brien, Geoff, Phil O'Keefe, Joanna Rose, and Ben Wisner. "Climate Change and Disaster Management." *Disasters* 30, no. 1 (2006).

⁹¹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 335

⁹² *Ibid.* 585

⁹³ Pew Charitable Trusts. "What We Don't Know About State Spending on Natural Disasters Could Cost Us." The Pew Charitable Trusts. June 19, 2019. <https://www.pewtrusts.org/en/research-and-analysis/reports/2018/06/19/what-we-dont-know-about-state-spending-on-natural-disasters-could-cost-us>.

instances of flooding.⁹⁴ FEMA's public assistance program has had eight of its ten most expensive operating years between 2007 and 2016 in part because of the increased frequency of these disasters.⁹⁵ Climate change is playing a major role in the increased frequency of these disasters as well.⁹⁶ When considering the challenges associated with climate change it is important for local governments to be aware of the potential costs associated with the provision of emergency services that they may face.

Finally, it is worth explicitly noting how some of the aforementioned issues with infrastructure and the economy could have cascading and compounding effects on each other. Flooding can shut down runways, railways, roads, and shipping canals.⁹⁷ The closure of major transportation networks such as these have cascading economic impacts, as products and people providing services are not able to move as they are supposed to. Additionally, if property is damaged and less property tax revenue is generated, that could have an impact on a state's ability to fund infrastructure maintenance. This would make infrastructure even more vulnerable to stressing floods. These issues do not happen in isolation, and comprehensive planning that considers how to simultaneously manage these intertwined issues is going to be a necessary component of a successful climate adaptation strategy.

Cultural Harms

⁹⁴ NOAA. "Calculating the Cost of Weather and Climate Disasters." National Centers for Environmental Information (NCEI). April 11, 2019. <https://www.ncei.noaa.gov/news/calculating-cost-weather-and-climate-disasters>.

⁹⁵ Pew Charitable Trusts. "What We Don't Know About State Spending on Natural Disasters Could Cost Us."

⁹⁶ NOAA. "Calculating the Cost of Weather and Climate Disasters."

⁹⁷ EPA. "Climate Impacts on Transportation."

The harms associated with flooding are not all material, quantitatively measured problems. Some of the problems caused by climate induced flooding will be cultural harms caused by the destruction of local resources and important ancestral locations. Sea level rise and its associated environmental harms are going to ensure that future generations “interact with the natural environment in ways that are different from today.”⁹⁸ Favorite beaches may become inundated. Tropical storms and constant flooding may make having positive interactions with the natural environment in some areas an incredible challenge. There would be substantial cultural harm as a result of “valued aspects of regional heritage and quality of life tied to ecosystems, wildlife, and outdoor recreation” being lost because of permanent changes in climate and habitability.⁹⁹ Additionally, areas that form a culture around an economic industry would likely suffer significant harms to their local culture as well. Communities in the Midwest that have been farming for generations or fishing communities along the Gulf of Mexico would struggle to reshape their identity if flooding decreases the economic viability of their industry.¹⁰⁰ This threat to culture applies to both coastal and rural areas, and many of the indigenous communities throughout the US.¹⁰¹ Some indigenous communities will face necessary relocation, raising major concerns about “maintaining cultural and community continuity.”¹⁰² Additionally, indigenous populations could have certain ancestral lands and populations of “culturally important species” be damaged by climate induced

⁹⁸ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 29

⁹⁹ Ibid., 29

¹⁰⁰ Ibid., 31

¹⁰¹ Ibid., 31

¹⁰² Ibid., 28

flooding.¹⁰³ Permanent community displacement in indigenous communities threatens to compound existing health issues prevalent in those communities while also likely creating a lot of mental stress for the displaced as well.¹⁰⁴ This is not a strictly hypothetical situation either. A federal grant has already been used in Louisiana to assist with the relocation of “the tribal community of Isle de Jean Charles” who have been forced to move to a new area because of coastal flooding caused by sea level rise.¹⁰⁵ In the midst of the discussion about harms associated with climate change, it is important to keep in mind the cultural harms that will occur in addition to the more quantitative harms.

Disadvantaged Populations

One final area that is worthy of discussion when looking at the negative consequences of climate induced flooding concerns how these harms will impact disadvantaged populations, like the impoverished or disabled. This is not a distinct harm of climate induced flooding, but rather just an acknowledgement of the fact that almost any negative impact would have a multiplied effect for the disadvantaged.¹⁰⁶ These populations suffer greater harms because they “have lower capacity to prepare for and cope with extreme weather and climate-related events.”¹⁰⁷ Specific examples of ways the disadvantaged suffer greater harms from these events include not having good enough healthcare to cover some health issues or injuries or populations that suffer from food insecurity having food shipments delayed because of issues with infrastructure and

¹⁰³ Ibid., 57

¹⁰⁴ Ibid., 57

¹⁰⁵ Ibid., 57

¹⁰⁶ Ibid., 25

¹⁰⁷ Ibid., 25

flooding.^{108 109} In some of the worst case sea level rise scenarios, more than half of the communities facing inundation by 2045 “contain areas of current high socioeconomic vulnerability.”¹¹⁰ For these reasons, actions taken to decrease the harms of climate induced flooding could be a significant benefit for disadvantaged populations.¹¹¹ The fact that disadvantaged populations stand to struggle more with the issues caused by climate induced flooding should be considered when looking at possible solutions.

The Role of State and Local Governments

This section sets out to briefly analyze the role state and local governments play in the fight against climate change and compare it to the role of the federal government. It will first highlight why state and local governments are uniquely positioned to combat the ill effects of climate change, primarily focusing on the fact that state and local government policymaking is less hampered by partisanship and the idea that these governments can use their power to create policies that are uniquely tailored to work in their specific area of the country. Following this, analysis will be performed regarding the ethical obligation local governments have to implement adaptive actions.

Partisanship

One reason state and local governments have an advantage in pursuing policies designed to minimize the harms of climate change is that they are less hampered by partisanship. This can be partially evidenced by the fact that many of the city councils in

¹⁰⁸ Ibid., 28

¹⁰⁹ Ibid., 57

¹¹⁰ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

¹¹¹ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 25

the country's largest cities do not have partisan affiliations.¹¹² Excess partisanship leads to ineffectiveness and a lack of compromise. Because of their current struggles with extreme partisanship, the federal government largely cannot be viewed as a reliable actor capable of being able to implement the policies that are needed to stem the impacts of climate change. The unreliability of the federal government is demonstrated by things like the increased frequency of government shut downs that result from partisan budget disagreements.¹¹³ Additionally, increased political polarization makes transitions between which party controls the executive branch even more extreme. It is tough to rely on the federal government as a consistent actor when every four years there is the chance for a dramatic shift in how climate issues will be approached. Because they are less partisan, local governments are uniquely positioned to take action to combat climate change, even in the face of ineffectiveness from the federal government. For example, the United States withdrew from the Paris Climate Agreement in 2017, a nonbinding international agreement signed by 195 nations aimed at limiting global temperature increase.¹¹⁴ Despite the indifference shown by the federal government, 407 mayors from across the country, dubbed the "Climate Mayors", joined together in agreeing to continue abiding by the regulations set out in the Paris Climate Agreement.¹¹⁵ These mayors, representing approximately 70 million citizens, are an example of how local governments can rise above the partisanship that hampers the federal government. At a time when hyper-

¹¹² National League of Cities. "Partisan vs. Nonpartisan Elections." <https://www.nlc.org/partisan-vs-nonpartisan-elections>.

¹¹³ Willis, Derek, and Paul Kane. "How Congress Stopped Working." ProPublica & The Washington Post. March 09, 2019. <https://www.propublica.org/article/how-congress-stopped-working>.

¹¹⁴ Shear, Michael D. "Trump Will Withdraw U.S. From Paris Climate Agreement." The New York Times. June 01, 2017. <https://www.nytimes.com/2017/06/01/climate/trump-paris-climate-agreement.html>.

¹¹⁵ Climate Mayors. "407 US Climate Mayors Commit to Adopt, Honor and Uphold Paris Climate Agreement Goals." June 1, 2018. <http://climatemayors.org/actions/paris-climate-agreement/>.

partisanship plagues our federal government, local governments are going to have to take advantage of their nonpartisan nature and shoulder the responsibility of preparing cities for the impacts of climate change.

Create Tailored Policies

State and local governments are also better able to tailor policies to an area's specific needs. This is why the 10th Amendment gives states the rights to create laws that do not conflict with federal law. This is also why taxation is largely determined at the local level. This has the benefit of allowing states to serve as "test labs" for democracy. This allows the creation of a sort of market of ideas where states can look to other states and see if they have good policies, figure out how those policies work, and adjust the policies to fit the specific needs or capabilities of their own community. In this free market approach to policymaking, states can adopt the policies that work for them and ignore the ones that do not. States that are threatened by climate change and flooding are going to need to creatively use the power given to them through the 10th amendment to combat these issues. Adaptation is an issue where local governments will need to take the lead because they have a better understanding for the needs and capabilities of their communities.¹¹⁶ They are able to better understand their communities because the "short distance between local administrators and their constituents" allows for better communication and understanding.¹¹⁷ Further, relative to the federal government, local governments are more engaged with local stakeholders and collaborators. This ability to

¹¹⁶ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 1311

¹¹⁷ Stowers, Genie N. L., Albert C. Hyde, and M. Ernita Joaquin. *Managing the Sustainable City*. New York, NY: Routledge, 2017, 59

engage in “regional collaboration” allows local governments to achieve greater policymaking effectiveness than other forms of government.¹¹⁸

Ethical Obligation of Governments

Governments have an ethical obligation to protect people and prevent harm where it is possible. This is supported by ethical theory concerning nonmaleficence, the commons, and the state of nature. A fundamental tenant of Western philosophy is the idea of nonmaleficence, which means people have an obligation to not cause harm.¹¹⁹ This ties into the obligations of governments when one considers the governments role is regulating the commons. One of the major commons issues facing governments right now is climate change. Innocuous individual actions have resulted in mismanagement of the environment and atmosphere, both non-rivalrous and non-excludable “goods”. At the point where people are jointly causing harm through individual actions, it becomes clear the government needs to intervene in their role as regulator of the commons.¹²⁰ The government has an obligation to regulate the commons and people have an obligation to not cause harm. Climate change is an example of how these obligations can intersect and create an ethical obligation for the government. It is also worth noting Thomas Hobbes’ discussions of the governments role as something that can protect people from the

¹¹⁸ Ibid, 46

¹¹⁹ Committee on Ethics Principles and Guidelines for Health Standards for Long Duration and Exploration Spaceflights; Health Standards for Long Duration and Exploration Spaceflight: Ethics Principles, Responsibilities, and Decision Framework. Washington (DC): National Academies Press (US); 2014 Jun 23. 5, Recommendations for Ethics Principles. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK222150/>

¹²⁰ Hardin, Garrett. "The Tragedy of the Commons." *Science*, New Series 162, no. 3859 (December 13, 1968): 1243-248.

inconveniences of the “state of nature.”¹²¹ Having to deal with flooding could be considered part of the “state of nature” Hobbes discusses. If we think of the government as something that is supposed to protect people from the “state of nature” than it is clear the government has an ethical obligation to protect people from the effects of climate change.

At the point where extensive information has been produced about the potential impacts of climate change, this shows that policymakers have an ethical obligation to try to protect their citizens from the ill-effects of climate change, especially those impacts we can already identify or project the impacts of. Governments that do not properly prepare for climate change will be subjecting their citizens to incredible risk.¹²² By the middle of the century, climate induced events like flooding could cause hundreds of billions of dollars in annual damages.¹²³ It is important at this point to keep in mind that some degree of sea level rise is already locked in because of historical emissions levels.¹²⁴ The amount we are already locked into has the potential to transform coastal communities by mid-century.¹²⁵ There are trillions of dollars of resources in these coastal communities and governments are going to have to be proactive if they hope to protect these investments.¹²⁶ It is going to be imperative that governments are proactive in working to address these projected threats as well. Some disaster management strategies that require

¹²¹ Williams, Garrath. "Thomas Hobbes: Moral and Political Philosophy." Internet Encyclopedia of Philosophy. Accessed May 15, 2019. <https://www.iep.utm.edu/hobmoral/>.

¹²² States at Risk. "States at Risk National Summary.", 1

¹²³ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 1314

¹²⁴ Ibid., 42

¹²⁵ Ibid., 31

¹²⁶ Nichols, “Ranking of the World’s Cities Most Exposed To Coastal Flooding Today and in the Future.”, 9

the construction of infrastructure can take a long time to complete, like the Thames Barrier in the UK that took nearly thirty years to construct.¹²⁷ This is on the high-end of time it could take to construct defenses, but it illustrates the fact that if cities want to be prepared for the impacts of climate change that are projected to occur by mid-century they are going to need to take action now, otherwise they risk being too late.

Governments must acknowledge that these projects take time to implement and take a proactive stance, or risk suffering unnecessary negative consequences. Governments have an ethical obligation to provide support where they can. As more understanding is built about what the impacts of climate change will be, policymakers have an ethical obligation to recognize those challenges and adopt policies and programs that will mitigate the associated harms. Further, some necessary climate investments may not make economic sense for private investment firms to engage in because they may not generate revenue. If one views climate adaptation infrastructure as a public good, similar to something like national defense, then the justification for intervention is clear. If a private entity could better solve the problem, governments would not have an ethical obligation to intervene, as they are not the best actor to intervene. However, if one views this issue as a market failure that justifies government intervention, then the government does have an ethical obligation to do so.

The government's obligation to provide support is only strengthened by the fact that research shows early intervention and implementation of adaptation strategies could provide significant benefits. This is because governments only have an obligation to

¹²⁷ Ibid., 10

intervene insofar as they will actually be able to provide help. At the point where intervention is expected to provide benefits and increase general welfare, the government's ethical obligation to intervene grows stronger. For example, if adaptation measures are implemented at an appropriate time more than half of the projected damages to coastal property can be avoided.¹²⁸ This is also only through the use methods and technology that are currently available.¹²⁹ If there are technological advancements in this area, one would only expect the amount of property that can be saved would increase. Additionally, sectors beyond the coastal property also stand to have their potential losses cut by more than half if proper adaptation measures are implemented.¹³⁰ For example, road and rail infrastructure are "capable of reducing damages by large fractions" if proactive adaptation measures can be implemented.¹³¹ These measures are going to require politically difficult, large upfront investments that involve extensive planning and many stakeholders.¹³² While the upfront cost of these projects will be difficult to swallow for some, if executed properly they should be able to save governments billions to maybe even trillions of dollars in the long-term, not to mention the fact that this will provide nonmonetary benefits like decreases in suffering.¹³³ ¹³⁴ The

¹²⁸ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 31

¹²⁹ Ibid., 63

¹³⁰ Ibid., 62

¹³¹ Ibid., 62-63

¹³² Ibid., 62

¹³³ Hinkel, Jochen, Daniel Lincke, Athanasios T. Vafeidis, Mahe Perrette, Robert James Nicholls, Richard S.J. Tol, Ben Marzeion, Xavier Fettweis, Cezar Ionescu, and Anders Levermann. "Coastal Flood Damage and Adaptation Costs under 21st Century Sea-level Rise." *Proceedings of the National Academy of Sciences*, 111, no. 9 (March 4, 2014): 3292-297. doi:<https://doi.org/10.1073/pnas.1222469111>. https://www.eenews.net/assets/2014/02/04/document_ew_01.pdf, 3292

¹³⁴ Wing, et al., "Estimates of Present and Future Flood Risk in the Conterminous United States.", 6

implementation of adaptation policies “at the city-scale are potentially great.”¹³⁵ This is why it is so vital that governments start acting now. This is not something that will be able to be done with a snap of the fingers. Finally, it is worth noting that among potential climate related harms, states are generally more prepared for coastal flooding than other threats, but incredibly unprepared for inland flooding, with 15 of the states that face the biggest threat having no official action plan outlining how to deal with the threat.¹³⁶ So while some areas have recognized this obligation, it is clear that other areas have much work to do to meet their ethical obligation to protect their citizens from preventable harm.

Potential Adaptation Actions

Now that it has been established that local governments have an obligation to assist with the implementation of climate adaptation actions, it is possible to move into a discussion of what potential climate adaptation action could look like. Adaptation actions include “forward-looking infrastructure design, planning, and operational measures and standards.”¹³⁷ The first type of actions are related to planning and the establishment of new standards aimed at improving resiliency in the face of climate change. The second type focuses on different types of specific infrastructure projects that can help individuals adapt to climate induced flooding, such as constructing sea walls and other manmade blockades, embracing the ability of some ecosystems to provide natural flood control, and developing systems to control and reroute flood waters.

¹³⁵ Nichols, “Ranking of the World’s Cities Most Exposed To Coastal Flooding Today and in the Future.”, 9

¹³⁶ States at Risk. "States at Risk National Summary.", 3

¹³⁷ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 30

Planning and Standards

The implementation of standards and planning requirements that consider the impacts of climate induced flooding are going to be important climate adaptation actions. One of the major adaptation actions that has already been seen but will continue to be needed is land use planning that focuses “new development away from the floodplain.”¹³⁸ The idea here is that as cities consider their economic development patterns, they should try to concentrate growth areas in spaces of the city less prone to flooding. This often means either discouraging coastal development, encouraging development in more elevated areas, or both. Another critical aspect of adaptive planning is “identifying critical infrastructure components” that are threatened by flooding.¹³⁹ Understanding where vulnerabilities exist better prepares cities to respond if those vulnerabilities are exposed. When cities are better prepared to deal with these events less suffering is likely to occur. Additionally, good planning and awareness of infrastructure vulnerabilities helps cities to identify how to take advantage of natural “capital stock turnover.”¹⁴⁰ Replacing already deteriorating infrastructure with more climate conscious infrastructure is a smart way for cities to implement adaptation actions. In addition to climate conscious planning, the implementation of climate conscious building and operation standards also has the potential to be a beneficial climate adaptation action. Examples of this could include retrofitting of certain buildings to improve their preparedness for flooding or

¹³⁸ Nichols, “Ranking of the World’s Cities Most Exposed To Coastal Flooding Today and in the Future.”, 9

¹³⁹ Hummel, et al. "Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts." *Earth's Future*, 6 (2018): 622-33. doi:10.1002/2017EF000805., 622

¹⁴⁰ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 1326

expanding standards new buildings will have to meet to be approved for construction.

The implementation of environmentally conscious standards and planning procedures are important parts of a climate adaptation strategy for any city.

Coastal Hardening

Another potential adaptation action an area could implement would be to deploy coastal hardening techniques. The idea is that climate induced flooding is going to require “upgraded protection”, and building protective infrastructure, like a wall or levee, along the coast can provide this protection.¹⁴¹ The use of sea walls and bulkheads has long been the go-to solution for areas that fear coastal flooding.¹⁴² Approximately 14% of the US coastline is already protected by some form of coastal hardening. Cities that have used these systems have shown that they can have a notable and positive impact on “community-level flood severity.”¹⁴³ The idea with these systems is rather simple. Sea levels are rising, so build a wall along the coast that can compensate for those increased levels. This way, instead of causing a flood, the waters will be stopped by the wall. Coastal hardening is an intuitive adaptation strategy that has long been used to combat the ill-effects of coastal flooding.

While this method has been shown to decrease the severity of some floods, there are some rather major concerns with coastal hardening that need to be addressed as well.

¹⁴¹ Nichols, “Ranking of the World’s Cities Most Exposed To Coastal Flooding Today and in the Future.”, 9

¹⁴² Gittman, Rachel K., F. Joel Fodrie, Alyssa M. Popowich, Danielle A. Keller, John F. Bruno, Carolyn A. Currin, Charles H. Peterson, and Michael F. Piehler. "Engineering Away Our Natural Defenses: An Analysis of Shoreline Hardening in the US." *Frontiers in Ecology and the Environment*, 13, no. 6 (August 1, 2015): 301-07. doi:10.1890/150065.

¹⁴³ Dahl, et al. , "Effective Inundation of Continental United States Communities with 21st Century Sea Level Rise."

Coastal hardening has been shown to cause a number of environmental harms related to erosion and the loss of beach and tidal ecosystems.¹⁴⁴ Coasts that have been hardened have shown noted decreases in habitat and biodiversity.¹⁴⁵ This raises major questions about how to prepare for floods without causing environmental harm for some areas of the United States. For example, more than 50% of the South Atlantic and Gulf of Mexico coasts have tidal wetland ecosystems that would be threatened if coastal hardening were to be constructed.¹⁴⁶ These areas are going to have to grapple with the decision to use shoreline hardening that could harm precious ecosystems or risk subjecting themselves to flooding as sea level rises. Luckily for these areas, sea walls and coastal hardening are not the only ways to control flooding.

Environment Restoration

While coastal hardening may be the most common manmade solution to flooding, certain ecosystems and environmental conditions can provide natural flood control that offers comparable protection to manmade structures without some of the aforementioned concerns pertaining to erosion and ecosystem loss. For example, beach replenishment is expected to be able to reduce a significant amount of the projected damages coastal properties face.¹⁴⁷ Coastal beaches are naturally dynamic ecosystems and are able to reduce the harms of floods if we allow them to. Beyond just beach replenishment,

¹⁴⁴ Gittman, et al., "Engineering Away Our Natural Defenses: An Analysis of Shoreline Hardening in the US."

¹⁴⁵ NOAA. "What Is a Living Shoreline?" June 25, 2018. <https://oceanservice.noaa.gov/facts/living-shoreline.html>.

¹⁴⁶ Gittman, et al., "Engineering Away Our Natural Defenses: An Analysis of Shoreline Hardening in the US."

¹⁴⁷ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 63

restoration of coastal marshes and wetlands offer even more potential for flood control.¹⁴⁸

Marshes and wetlands help with flood control in several ways. One thing they do is absorb wave energy. 15 feet of marsh has the potential to absorb 50% of incoming wave energy, dramatically reducing the intensity of the waves reaching the shore.¹⁴⁹

Additionally, wetlands help reduce flood intensity by acting as a sort of “sponge” capable of absorbing floodwater before it can get to the shore and releasing it slowly enough to avoid shocks.¹⁵⁰ These factors make wetlands a valuable natural source of flood protection. If used correctly, wetlands can provide levels of flood control comparable to those achieved through the use of “expensive dredge operations and levees.”¹⁵¹ One example of this being done is in Massachusetts, where the Tidmarsh Wildlife Sanctuary has been established. The area the sanctuary occupies was formerly a coastal cranberry farm, but it is now an area used to monitor the interactions between climate change, flooding, and wetlands.¹⁵² They have embraced the natural qualities of the wetland and use it not only to protect themselves, but to collect data about the impacts it has on controlling flood waters and sea level rise in the area so that other areas may better understand how they can utilize their wetlands. In addition to stemming the impacts of flooding, wetlands also yield numerous other benefits, such as providing a home for multitudes of species including “microbes, plants, insects, amphibians, reptiles, birds, fish and mammals”, improving water quality, controlling shoreline erosion, and presenting

¹⁴⁸ Ibid., 1322

¹⁴⁹ NOAA. "What Is a Living Shoreline?" June 25, 2018. <https://oceanservice.noaa.gov/facts/living-shoreline.html>.

¹⁵⁰ EPA. "Why Are Wetlands Important?" June 13, 2018. <https://www.epa.gov/wetlands/why-are-wetlands-important>.

¹⁵¹ EPA. "Why Are Wetlands Important?"

¹⁵² Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 1322

opportunities for recreation and aesthetic appreciation.¹⁵³ For these reasons, the use of wetlands as a natural flood control system should be seriously considered in relevant areas. Wetlands offer a way to control flooding that is more environmentally friendly and, in some instances, just as effective as shoreline hardening. Policymakers considering using shoreline hardening techniques should consider if there is any way to replace or supplement the hardening with natural protection techniques like beach replenishment or wetland restoration. One final thing to consider here is that it will likely be difficult for projects based on habitat restoration to get private financing, as they do not really generate returns for investors in the same way other investment might.¹⁵⁴ This means that government involvement is likely going to be necessary if these types of projects have any hope of being implemented.

Flood Water Diversion

The final adaptation action included here is the use of canal or other drainage systems that channel and divert flood waters away from where they would do the most harm. These sorts of systems are standard in most cities, but as climate change threatens to increase the severity of floods, cities may have to increase the amount of resources they have dedicated towards these systems. Fargo, North Dakota, is one such city that is taking dramatic action to prepare for flooding. Fargo often struggles with flooding from the Red River, and with flooding only projected to increase, they decided to invest in a 2.75 billion dollar plan to build a canal that will divert floodwaters thirty miles around the

¹⁵³ EPA. "Why Are Wetlands Important?"

¹⁵⁴ Spratt, Stephen, and Christina Ashford. "Climate Finance: A Tool-kit for Assessing Climate Mitigation and Adaptation Funding Mechanisms." December 2011.

https://unfccc.int/sites/default/files/climate_finance_and_the_financial_transaction_tax.pdf, 19

city and spare them from future flooding events.¹⁵⁵ Bold investments like these have the potential to reduce flood damages for proactive cities and regions that have the political will to make them. These types of projects may work best for areas like North Dakota that may suffer mostly from inland flooding, but similar concepts could also be used to help channel coastal flood waters away from areas that have the most to lose. Water diversion techniques are a proven method of flood control that has potential to be used to adapt to the negative consequences of climate change.

¹⁵⁵ Vock, Daniel C. "North Dakota's Massive, \$2.75 Billion Effort to Avoid Floods." March 12, 2019. <https://www.governing.com/topics/transportation-infrastructure/gov-fargo-flood-prevention-north-dakota-climate-change.html>.

TABLE 2: Summary of Potential Adaptation Actions

Example Projects	What does it do?	How does it work?	What are the benefits?
1) Planning / Standards			
a) Land Use / Development Planning	Concentrates development outside of the floodplain	Discourages coastal development and/or encourage development in elevated areas	Protects future value of investments and limits future damages in case of flooding
b) Infrastructure Planning	Identifies vulnerable or deteriorating infrastructure	Replaces vulnerable or already deteriorating infrastructure with climate conscious infrastructure	Less harms caused by damages to infrastructure
c) Building Standards	Ensures new developments can withstand future flooding events	Requires new buildings to meet a higher standard of flood resiliency	Ensures safety of new buildings and limits future damages
d) Retrofits	Increases the flood resiliency of older buildings	Older buildings are "retrofitted" with upgrades that will help protect them in a flood	Helps maintain property values and limit future damages
2) Coastal Hardening			
a) Sea Walls and Levees	Protects vulnerable coastal areas from rising sea levels	Builds walls along coasts that compensate for higher sea levels	Decreases flood severity and protects coastal properties
3) Environmental Restoration			
a) Beach or Wetland Restoration	Provides natural means of flood control for vulnerable areas	Takes advantage of an ecosystem's natural ability to absorb flood waters and wave energy	Provides a more environmentally friendly method of flood control
4) Flood Water Diversion			
a) Canal or Drainage System Construction	Diverts flood waters away from critical areas	Uses manmade channels or drainage systems to collect and control flood waters	Limits flooding in critical areas and increases predictability of where flooding will occur

Tax Policy as an Implementation Tool

State and local governments can also use taxes to implement climate adaptation actions. Local governments have a number of tools they can use to implement these policies, but for the purposes of this paper, I will focus specifically on their use of tax manipulation. This paper chooses to focus on tax manipulation because it is handled primarily at the local level. Further, taxes are malleable and can be manipulated to meet the needs and capabilities of a specific community. This makes them an especially powerful tool for local governments. Analyzing how this tool works requires specifically looking at how governments can help to implement climate adaptation action by manipulating existing taxes, creating new taxes, issuing tax credits, and establishing special economic districts. These methods of tax manipulation make it possible for governments to both invest in projects that can help mitigate the harms of climate change and influence the market with positive and negative incentives. The use of tax incentives are also often more politically popular than policies that implement new rules or regulations, implying people prefer to be incentivized rather than told what to do.¹⁵⁶ Adaptation is going to involve risky investments and large upfront costs which increases the salience of implementing policies that reduce those costs and risks.¹⁵⁷

Manipulate Existing Rates / Create New Taxes

The first way tax policy can be used to help implement adaptation actions is through the manipulation of existing rates or through the creation of new taxes. While they are separate ideas, these two concepts are often interconnected and will therefore be

¹⁵⁶ Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*, 56

¹⁵⁷ Reidmiller, et al., "Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.", 1326

analyzed in tandem. For example, one global strategy used to fund climate adaptation projects involves phasing out fossil fuel subsidies and using the newly acquired revenue to fund the projects.¹⁵⁸ This example shows how, depending on one's perspective, a shift in tax policy could be viewed as either manipulation of existing rates or the creation of a new tax. Removing the subsidies for fossil fuel companies is technically manipulating existing rates, but functionally is like the implementation of a new tax. The tax is not new, the companies just haven't had to pay it before, so it feels like a new tax. This shows how these two concepts can be interconnected. Additionally, this shows how tax rate manipulation offers good opportunities to pursue both mitigation and adaptation actions. The tax increase for fossil fuel companies will mitigate climate change impacts because it weakens a polluting industry and the funds raised from the tax increase will be used to fund climate adaptation actions. Another potential example of this would be implementing a carbon tax and using the funds to support adaptation projects. The carbon tax helps mitigate pollution by creating a negative incentive to do so while the funds it raises help fund adaptation projects. It is worth noting that the cost of these taxes could also potentially be passed down to the consumer. However, this could still create a mitigating effect if consumers substitute away from polluting companies because they increased their prices. While these types of taxes provide opportunity for overlap, the tax source does not need to be based in mitigation. For example, the flood water diversion project being implemented in Fargo, North Dakota is being paid for through an increase in the local sales tax that will be in effect until 2084.¹⁵⁹ Having a revenue source is going

¹⁵⁸ Spratt, "Climate Finance: A Tool-kit for Assessing Climate Mitigation and Adaptation Funding Mechanisms.", 24

¹⁵⁹ Vock "North Dakota's Massive, \$2.75 Billion Effort to Avoid Floods."

to be a necessity for the implementation of any sort of climate adaptation action. Policymakers will often have to get creative with how they choose to fund adaptation strategies, as their lack of natural funding source will likely require the manipulation of existing rates or the implementation of an entirely new tax.

Tax Credits

Governments often uses tax credits to incentivize behaviors they find desirable. Further, tax credit programs are largely viewed as a way to encourage development while avoiding the higher costs of other methods such as “regulatory or spending measures.”¹⁶⁰ This section will look at numerous examples of how tax credits can be used to incentivize and subsidize adaptation projects. Before moving into these examples it is important to note that in the short-run implementing these tax credits will likely decrease the government’s tax base, reducing their ability to fund other programs or services.¹⁶¹ However, if policymakers keep this in mind and compensate their budgets accordingly tax credits can be an incredibly powerful tool. One common tax credit with clear application to adaptation projects is the use of preferential assessments.¹⁶² There are several real world examples of programs similar to this policymakers could use to build their own policies from. At the federal level, the Farm Service Agency (FSA) administers the Conservation Reserve Program (CRP), which pays farmers to remove “environmentally sensitive” land from agriculture use so that it can be restored to proper levels of environmental health.¹⁶³ A similar state level program in North Carolina, the

¹⁶⁰ Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*, 56

¹⁶¹ *Ibid.*, 56

¹⁶² *Ibid.*, 54

¹⁶³ USDA. "Conservation Reserve Program." June 1, 2018. <https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/>.

North Carolina Conservation Tax Credit Program, offered landowners a one-time tax credit, applied to state income tax, if they dedicated parts of their land towards “conservation purposes.”¹⁶⁴ It is not difficult to reimagine these policies as policies that incentivize adaptation actions. An example of this would be offering lower property tax assessments to property owners who preserve things like wetlands on their property that can help control flooding.

So far there has only been discussion pertaining to preservation incentives, meaning individuals are being incentivized not to do something. Tax credits can also be used to pursue incentives aimed at encouraging construction and development in certain areas. For example, South Carolina has a program where homeowners who buy materials to retrofit their homes with the goal of making them more resilient to storms are given a tax credit to help offset the cost of the materials.¹⁶⁵ Depending on the situation, local governments could offer a one-time or continuing tax credit aimed at encouraging the development of more flood resistant homes and businesses. Policymakers looking to implement adaptation actions should consider using tax credits to incentivized certain behavior that can be encouraged rather than mandated.

Special Economic Districts

Finally, the use of special economic districts will be analyzed. This tool is closely tied to tax credits, with the key difference being special economic districts often offer tax credits that can only be applied to property within the district. Typical tax credits are less

¹⁶⁴ Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*. 55

¹⁶⁵ *Ibid.*, 56

geographically restricted. A lot of the ideas in tax credits could be cross-applied into special economic districts just by putting a boundary on the area that is eligible for the tax credit. For example, the use of conservation or preservation credits was discussed. A city could identify areas of the city it thinks could benefit from having open space for flood control and then offer a tax credit to residents of that area who agree to leave the space open.¹⁶⁶ Because the tax credit is only offered in a specific area, it creates a special economic district. While the two concepts are closely related, special economic districts are a distinct tool that offer more than just tax credits. It is important to keep in mind concerns related to inequality and disadvantaged populations when looking at some of these districts as well. While more affluent populations can often readily respond to incentives, disadvantaged populations may not be able to do so. As such, it is important to consider how the creation of negative incentives or the removal of revenue from the general fund could impact these groups. This section will look at different types of special economic districts and explain how they can be used to aid the implementation of climate adaptation actions.

One of the most commonly used special economic districts is the Business Improvement District (BID). A BID is a district within a municipality, typically commercial, that self-imposes higher property taxes that are then used to fund improvements within the district. BIDs are unique because they raise taxes, rather than providing things like preferential assessments. BIDs are typically dedicated towards issues such as improving roads, increasing security, or dedicating more resources to

¹⁶⁶ Ibid., 55

keeping an area clean. However, this same concept could be applied to fund things like seawalls or canals that redirect flood waters. These types of projects are going to be expensive and will disproportionately benefit residents and businesses who live in the floodplain. Developing BIDs that encompass commercial districts threatened by potential flooding would provide a way for those entities to invest more in the protection they will be receiving. BIDs are already used throughout the country to fund development projects. There is no reason these districts could not be used to help raise the funds needed to protect vulnerable areas. Additionally, in the status quo, because they are used primarily to drive economic development, these districts are only used commercially. However, investing in climate adaptation projects is not the same as typical BID investments. For this reason, it may be worth considering allowing something similar to a BID to be implemented in a residential area, as it could help vulnerable residential areas to pool their resources and invest in adaptation projects that can save their properties. BIDs are a proven economic development tool with strong potential to assist in the implementation of different climate adaption projects.¹⁶⁷

The next type of district to be analyzed will be sending and receiving districts. These districts can be used to help relocate properties out of flood prone areas and concentrate development in more hospitable areas. These types of districts take several forms, as they either have a sending district, a receiving district, or both. “Sending districts” are districts where development is disincentivized. Sending districts would receive benefits like a relocation tax credit that helps offset the cost of moving out of the

¹⁶⁷ Armstrong, Amy, Ingrid Gould Ellen, Amy Ellen Schwartz, and Ioan Voicu. "The Benefits of Business Improvement Districts: Evidence from New York City." July 2007. <http://furmancenter.org/files/publications/FurmanCenterBIDsBrief.pdf>, 1

sending zone.¹⁶⁸ Sending zones primarily use positive incentives like this, as negative incentives, such as raising tax rates to discourage investment in the district, would likely be politically unpopular. People like positive incentives because they feel less coercive.¹⁶⁹ “Receiving districts” are similar to sending districts, but instead of using positive incentives to move people out of an area, positive incentives are used to attract development to a specific area. Whereas sending areas are typically high-risk, receiving areas would likely be urban, underdeveloped, elevated areas that would be more protected in the case of a flood.¹⁷⁰ Receiving districts could offer preferential assessments in the receiving district or offer things like density bonuses to developers to encourage them to cluster their development in these areas.¹⁷¹ Sending and receiving districts can be used in isolation or in tandem. When used together they can be an effective adaptation tool, as the government can use planning to move people out of flood prone areas and into safer arrangements. Additionally, if they can get sending zone to be vacated, they will likely be prime areas to construct different types of flood control infrastructure, like major sea walls. This demonstrates how the use of sending and receiving district can help cities prepare for climate induced flooding.

One final type of economic district that needs to be analyzed is a tax increment financing (TIF) district. TIF districts are a tool commonly used by municipalities to redevelop blighted areas that would not see any development without an incentive to do

¹⁶⁸ Grannis, *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*, 55

¹⁶⁹ *Ibid.*, 56

¹⁷⁰ *Ibid.*, 57

¹⁷¹ *Ibid.*, 55

so.¹⁷² Typically, as an area is developed, the property owners there see their property tax bill go up because of the value being added to their property and the neighborhood. TIF districts allow people to reinvest the higher taxes they would normally pay because of development into a specified project for a fixed amount of time. This is done by splitting the tax revenue into two groups: base revenues and incremental revenues. The base revenues are based on the assessed value of the TIF district's properties at the time of establishment. Base revenues are fixed, and do not change throughout the life of a TIF. All the additional tax revenue collected above the base revenue is classified as incremental revenue. This is the revenue that is generated by the development of the district. The taxes paid into the base revenues are being used to fund schools and local services the same as property taxes paid anywhere else in the municipality. The incremental revenue, raised because of the increased value of properties within the district, is allocated to a special fund that is used "to underwrite projects within the TIF district and to provide development subsidies to encourage growth."¹⁷³ For the purposes of climate adaptation, a TIF could be used in a community where property values and investment are falling because of concerns regarding projected flooding. For example, in Virginia Beach, a TIF is being used to fund a beach replenishment program that will protect the city from flooding events.¹⁷⁴ This TIF allows the area to maintain its viability as a tourist destination and continue to attract investment. With TIFs, some initial funding may be needed to get the project off the ground and property values going up. However,

¹⁷² Greifer, Nicholas. "An Elected Official's Guide to TAX INCREMENT FINANCING." 2005. <https://www.gfoa.org/sites/default/files/EOGTIF.pdf>. pg. 5

¹⁷³ Ibid., 3-4

¹⁷⁴ City of Virginia Beach. Fiscal Year 2017 Adopted Operating Budget. 2017. 56

once development begins to occur and property values rise, the incremental revenue generated by the TIF can be used to provide additional investment. TIFs can be a valuable resource for struggling communities that would likely not see much development or investment if there was not an additional incentive to do so.

TABLE 3: Summary of Taxes as an Implementation Tool

Example Taxes	How does it work?	What are the benefits?
1) Manipulate Existing Rates / Create New Taxes		
a) Repeal Subsidies for Polluting Industries	Remove tax breaks for polluting industries and use increased revenues to fund projects	Creates a new revenue stream that could fund projects or be used to shift subsidies to different industries
b) Implement Mitigation Tax	Impose new tax on industries that disincentivizes polluting and generates funds for projects	Creates disincentive for pollution while also bringing in revenue to fund projects
c) Increase Existing Rates	Fund projects by increasing local tax rates on things like sales, income, or property taxes	Local governments can tailor their taxes to fit their regions needs and capabilities
2) Tax Credits		
a) Environmental Preservation Credit	Pay property owners who preserve parts of their land that can naturally help control floods	Provides natural flood control with the cost being lost revenue rather than additional expenditure
b) Resiliency Credit	Pay property owners who make upgrades on their property that make it more resilient to flooding	Maintains property values in the long-term which helps preserve property tax revenue
3) Special Economic Districts		
a) Business Improvement Districts	Area self-imposes higher taxes to provide revenue that can be used to fund projects	Allows well-off districts to invest in themselves without increasing the tax burden on other areas
b) Sending / Receiving Districts	Tax incentives are offered to encourage relocation (sending) or development (receiving) in specific areas based on their level of vulnerability	Potentially tax-neutral way to use incentives and market-based tools to implement land use planning objectives
c) Tax Increment Financing Districts	Struggling areas invest in development projects and pay for them over time with the property tax revenue generated by the development	Enables development by allowing struggling areas to keep their taxes in the district

Conclusion

Climate change has reached the point where a certain amount of global temperature increase and sea level rise is locked in. These factors are going to make implementing adaptation projects a necessity, regardless of the success of mitigation projects. Local policymakers are uniquely situated to tackle these projects and will be the first to deal with the negative consequences if they fail to take appropriate action. This paper hopes to provide a decision-making tool for local policymakers looking to implement adaptation projects. Currently, much of the literature surrounding the policy response needed for climate change is based around mitigation action taken by the federal government. The unique contribution of this paper is that it acknowledges the inevitability of the impacts of climate change and frames the issue as an adaptation issue that will need to be handled by local governments. This paper began by providing background context through discussions of how climate change and flooding, the locations in the US most susceptible to flooding, and the role of state and local governments before providing specific examples of potential climate adaptation projects and explaining how taxes can be used to help implement these products.

There are a number of major takeaway points from this paper that should be kept in mind. Federal politicians have the luxury of debating climate changes causes without having to deal with the on the ground adaptation that will be needed regardless of the cause of the flooding. It is known that some degree of adaptation will be necessary because historic emissions levels have already committed the world to a certain degree of sea level rise and associated flooding. This flooding is projected to occur in all areas of the US and has the potential to cause major damage to infrastructure, the economy, and

culture, with disadvantaged populations suffering from these challenges even more than the average citizen would. However, it was established that much of the projected damage can be stopped if timely investments are made into appropriate adaptation projects. This makes understanding how to identify optimal solutions and implement them incredibly important. There are various positives and negatives associated with any adaptation action and method of implementation. If quality of life standards are going to be maintained in the US, major climate adaptation projects will have to be implemented throughout the US, and as such, there is a need for research that helps policymakers make informed and calculated decisions regarding their community's future.

Finally, I will conclude with a discussion of some of the limitations of this paper were and how this research could be built upon in the future. The effectiveness of any of these projects is potentially limited by the unreliability of climate research. For example, current projections about sea level rise could be undershooting what will actually happen. If projects are developed with his projection in mind, they will not be prepared to adequately deal with the sea level rise that will be experienced. There is incredible uncertainty surrounding projections about what will happen to the environment because of climate change, and errors in these projections could have significant negative implications for policy makers if they do not consider them.

Another limitation of this project is that it was not able to provide a cost projection for different projects or a projected impact of revenues from the implementation of any of the tax policies discussed. Different regions have the country simply have too much variation for this paper to accurately make inferences into these costs. While this project was not able to look at this issue, it is an area that could be

researched further in the future. This would require using a typology to create classifications of cities based on different factors such as: population, rural/urban, and scale of flooding threat for example. Once these classifications were established more informed recommendations could be made regarding what type of policy or tax tool is most optimal for an area. This type of tool would allow an area to plug in their information and receive recommendations from the model about what the best course of action would be for them to take. While this project is not able to make specific recommendations, it does provide valuable information local decision makers can use to inform their decisions.

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