

# A Sinking World: A Model Framework for Climate Change Adaptation Measures in Coastal Cities

## ABSTRACT

*Climate change has already begun wreaking havoc on coastal communities across the globe, including Miami, Venice, and the Philippines. Adaptation mechanisms may be the most powerful weapons these communities have to combat sea level rise and the other disastrous effects of a warming planet. However, these adaptation programs must fit within each nation's unique federal and local regulatory schemes. Additionally, when they are funded by the federal government or foreign sources, these communities may have to sacrifice some autonomy over their implementation. While adaptation strategies can be broken down into three primary modes—resistance, transformation, and retreat—the most effective combination of each varies between developed and developing countries, the latter of which may possess fewer resources and less preexisting infrastructure. This Note analyzes Miami, Venice, and the Philippines as case studies in order to develop a model framework for adaptation mechanisms for coastal cities everywhere.*

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## I. INTRODUCTION

In the Northern Lido inlet to the Venetian Lagoon, beneath the surface of the Adriatic Sea, twenty-one massive steel floodgates lay in wait on the ocean floor.<sup>1</sup> Part of the *Modulo Sperimentale Elettromeccanico* (MOSE) project, the floodgates are engineered to protect the lagoon from the increasingly frequent “*acqua alta*” high tides and storm surges that threaten its islands and inhabitants.<sup>2</sup> Upon completion, the gates will provide protection by rising up during extreme weather events and—quite literally—holding back the ocean.<sup>3</sup>

MOSE is just one of the countless adaptation mechanisms that cities across the world are implementing in an effort to combat the disastrous effects of climate change, and rising sea levels in particular.<sup>4</sup> This Note will analyze the city of Miami and the greater South Florida region of the United States; the city of Venice, Italy; and the various municipalities of the Philippines as case studies, in order to explore the ways in which cities across the globe can utilize adaptation mechanisms to combat sea level rise. First, this Note will analyze each country’s federal, regional, and local regulatory frameworks. Second, it will explore the challenges that climate change

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1. See Ministry of Infrastructure & Transport, *MOSE: The mobile barriers for the defence from floods*, MOSE VENICE, <https://www.mosevenezia.eu/mose/?lang=en> (last visited Oct. 29, 2018) [<https://perma.cc/MF3Q-HP6M>] (archived Nov. 9, 2019) (video demonstrating resurrection of barriers).

2. Ministry of Infrastructure & Transport, *General Plans for Intervention*, MOSE VENICE, <https://www.mosevenezia.eu/project/?lang=en> (last visited Oct. 29, 2018) [<https://perma.cc/XN7Y-J7P4>] (archived Oct. 31, 2019).

3. *Id.*

4. See *infra* Part II.

poses to each of these coastal regions. Third, it will analyze the adaptation mechanisms each of these regions has implemented to address sea level rise and other climate change–related disasters. Fourth, it will examine the various sources of funding that each of these programs relies on, including what level of autonomy local communities reserve in implementing these programs when funding comes from a federal or international source. Finally, this Note will compare the successes and failures of each region’s adaptation strategies, given their nation’s regulatory structure and their source of funding. Based on this analysis, this Note will propose a model adaptation framework that can be exported to coastal cities around the world that are vulnerable to climate change.

## II. BACKGROUND

The MOSE floodgates serve as a reminder that climate change is no longer a contested issue in the scientific community, nor are its anthropogenic origins.<sup>5</sup> Based on a study of nearly twelve thousand scientific research papers, 97 percent of actively publishing climate scientists believe that climate change is both real and at least partially caused by human activity.<sup>6</sup> While Earth’s climate experiences natural cycles of warming and cooling, new paleoclimatic evidence has established that the current warming “is occurring roughly ten times faster than the average rate of ice-age-recovery warming.”<sup>7</sup> Although the planet’s average temperature has only risen by 1.62 degrees Fahrenheit since the nineteenth century, the majority of this increase has occurred over the last four decades, while industry blossomed in developing nations and boomed in developed ones.<sup>8</sup> The staggering amounts of carbon dioxide and other man-made emissions that human activity has released into the atmosphere have contributed to this warming by trapping the sun’s rays inside our atmosphere in what has come to be universally known as the “greenhouse effect.”<sup>9</sup>

The consequences of this warming have the potential to be globally devastating. Around the world, ice sheets are shrinking, and glaciers

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5. See John Cook et al., *Quantifying the Consensus on Anthropogenic Global Warming in Scientific Literature*, 8 ENVTL. RES. LETTERS 1 (2013) (stating that there is a 97% consensus among climate scientists on the existence of anthropogenic global warming).

6. *Id.*

7. *Id.* (citing NAT’L RES. COUNCIL, SURFACE TEMPERATURE RECONSTRUCTIONS FOR THE LAST 2,000 YEARS (2006)).

8. *Climate Change: Vital Signs of the Planet*, NAT’L AIR & SPACE ASS’N, <https://climate.nasa.gov/evidence/> (last updated Oct. 15, 2018) [<https://perma.cc/K8BD-GGYG>] (archived Oct. 26, 2019) [hereinafter *Vital Signs*].

9. Hilary Costa et al., *Greenhouse Effect*, NAT’L GEOGRAPHIC, <https://www.nationalgeographic.org/news/greenhouse-effect/12th-grade/> (last updated May 18, 2018) [<https://perma.cc/B54Z-FQMY>] (archived Jan. 20, 2020).

are retreating as they melt.<sup>10</sup> All that water has to go somewhere—and it has. The global sea level rose eight inches over the last hundred years, and the rate at which it is rising has doubled in the last two decades.<sup>11</sup> Hundreds of cities in the United States alone are projected to face persistent flooding as the sea rises—these include Cambridge in Massachusetts, Oakland in California, Miami and St. Petersburg in Florida, as well as four out of five boroughs in New York City.<sup>12</sup> Many low-lying areas will become uninhabitable well before they are permanently submerged; residents tend to flee from chronically flooded areas “decades before [they] are permanently inundated.”<sup>13</sup> Other major cities facing impending flooding include London, Shanghai, and Jakarta.<sup>14</sup>

Cities across the globe are also experiencing more frequent extreme weather events.<sup>15</sup> These include more intense tropical cyclones,<sup>16</sup> which move slower, drop more rain, subject communities to high winds for longer periods of time, and cause more devastating storm surges and flooding.<sup>17</sup> Warmer air and sea temperatures increase the number of cyclones and the amount of rain these storms drop.<sup>18</sup>

Climate change’s impacts also include megadroughts, like those that are projected to impact the western United States later this

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10. *Vital Signs*, *supra* note 8.

11. See generally R.S. Nerem et al., *Climate-change-driven Accelerated Sea-level Rise Detected In The Altimeter Era*, in PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA (Anny Cazenave et al. eds., 2018) (describing a study on rising sea levels).

12. Laura Parker, *Sea Level Rise Will Flood Hundreds of Cities in the Near Future*, NAT’L GEOGRAPHIC (July 12, 2017), <https://news.nationalgeographic.com/2017/07/sea-level-rise-flood-global-warming-science/> [<https://perma.cc/68Z9-CD4U>] (archived Oct. 26, 2019).

13. *Id.*

14. See Fiona Harvey, *From London to Shanghai, World’s Sinking Cities Face Devastating Floods*, GUARDIAN (Oct. 4, 2018), <https://www.theguardian.com/environment/2018/oct/05/from-london-to-shanghai-worlds-sinking-cities-face-devastating-floods> [<https://perma.cc/8855-U4CY>] (archived Oct. 26, 2019).

15. *Vital Signs*, *supra* note 8.

16. See *Global Warming and Hurricanes*, NOAA GEOPHYSICAL FLUID DYNAMICS LABORATORY, <https://www.gfdl.noaa.gov/global-warming-and-hurricanes/> (last updated Aug. 15, 2019) [<https://perma.cc/FWN7-9VFX>] (archived Oct. 26, 2019) (summarizing hurricane activity trends).

17. Craig Welch, *Hurricanes are Moving Slower—and That’s a Huge Problem*, NAT’L GEOGRAPHIC (June 6, 2018), <https://news.nationalgeographic.com/2018/06/hurricanes-cyclones-move-slower-drop-more-rain-climate-change-science/> [<https://perma.cc/52F4-QK4J>] (archived Oct. 30, 2019).

18. See generally Geert Jan van Oldenborgh et al., *Attribution of Extreme Rainfall from Hurricane Harvey, August 2017*, 12 ENVTL. RES. LETTERS 1 (2017) (analyzing the effect of increased temperature and therefore increased moisture in the air on storms).

century and could last up to thirty-five years.<sup>19</sup> What were once twenty-year droughts—so intense that they only occurred once every two decades—are now anticipated to occur biannually by the end of the century.<sup>20</sup> And in addition to droughts, inhabitants of cities like Bogotá<sup>21</sup> and Cape Town also face worsening pollution and diminishing air quality; these effects have immediate consequences for public health and safety.<sup>22</sup>

While mankind had a hand in engineering climate change and its disastrous effects, the MOSE floodgates serve as a reminder that scientists may also be able to engineer safety nets and protective measures that will offer solutions to these devastating consequences. Governments across the globe are implementing mitigation and adaptation measures in an attempt to adjust to and endure our changing climatic circumstances. Mitigation strategies are efforts aimed at preventing or lessening the impacts of climate change, while adaptation strategies are designed to deal with managing the impacts that do occur.<sup>23</sup> In other words, mitigation aims to avoid the unmanageable and adaptation aims to manage the unavoidable.<sup>24</sup> However, these two objectives are closely linked, and programs oriented at combatting climate change often accomplish both.<sup>25</sup>

Cities can adapt to the impacts of climate change using incredible feats of engineering and ingenuity. Within the United States, New Orleans is one of the most well-known examples of adaptation.<sup>26</sup> After

19. See Scientific Visualization Studio, SVS: *Megadrought in U.S. West Projected to be Worst of the Millennium*, NAT'L AIR & SPACE ASS'N (Feb. 12, 2015), <https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4270> [https://perma.cc/FV72-96Z6] (archived Oct. 26, 2019) (analyzing the probability of a megadrought).

20. *Id.*

21. See Maria Martinez, *Blooming Bogotá: How Cities Can Pave the Way for Climate Change Mitigation and Adaptation in Latin America*, NAT'L RES. DEF. COUNCIL (June 1, 2015), <https://www.nrdc.org/experts/maria-martinez/blooming-bogota-how-cities-can-pave-way-climate-change-mitigation-and> [https://perma.cc/9YYD-HT48] (archived Oct. 31, 2019) (describing measures taken by Bogota to mitigate climate change problems).

22. Patricia de Lille, *The Time for Air Pollution Action in Cape Town is Now*, HUFFINGTON POST (Jan. 23, 2018), [https://www.huffingtonpost.com/entry/time-for-climate-change-action-is-now\\_us\\_5a593ca5e4b0fcbc3a102865](https://www.huffingtonpost.com/entry/time-for-climate-change-action-is-now_us_5a593ca5e4b0fcbc3a102865) [https://perma.cc/5958-P4AZ] (archived Oct. 26, 2019).

23. See generally Chunli Zhao et al., *Adaptation and Mitigation for Combatting Climate Change – From Single to Joint*, 4 ECOSYSTEM HEALTH & SUSTAINABILITY 85, 85 (2018) <https://www.tandfonline.com/doi/full/10.1080/20964129.2018.1466632> [https://perma.cc/MV4A-JZ8B] (archived Oct. 26, 2019) (discussing differences and the relationship between adaptation and mitigation).

24. Rosina Bierbaum, *Confronting Climate Change: Avoiding the Unmanageable, Managing the Unavoidable*, UNIV. OF MD. (Mar. 6, 2017), [http://www.globalchange.umd.edu/data/indc/trondheim2017/Session-1\\_bierbaum\\_030517.pdf](http://www.globalchange.umd.edu/data/indc/trondheim2017/Session-1_bierbaum_030517.pdf) [https://perma.cc/L9KA-BHNT] (archived Jan. 20, 2020).

25. Julia Laukkonen et al., *Combining Climate Change Adaptation and Mitigation Measures at the Local Level*, 33 HABITAT INT'L 288, 288 (2009).

26. See *How 3 U.S. Cities Are Adapting to Climate Change*, WBUR (Sept. 21, 2016), <http://www.wbur.org/hereandnow/2016/09/21/us-cities-climate-change>

Hurricane Katrina ravaged the city in 2005, New Orleans improved its levees and constructed a maze of storm gates and floodwalls—including the largest storm surge barrier in the nation, affectionately referred to by some as “the Great Wall of New Orleans.”<sup>27</sup> Recognizing the inevitability of rising sea levels, though, the city has gone several steps further and created large-scale green infrastructure projects, including water gardens and parks that are able to absorb and retain whatever storm surge makes it past the city’s many barriers.<sup>28</sup> In Colorado, the city of Boulder has adapted to frequent flooding from its many neighboring rivers by implementing “micro power grids,” which minimize electrical outages during extreme flooding.<sup>29</sup> Los Angeles, one of the most drought-prone cities in the country, managed to reduce its water consumption by 20 percent, and the city has required residents to replace ornamental lawns with drought-resistant lawns to conserve water.<sup>30</sup>

Around the globe, cities are implementing resourceful adaptation strategies to delay or reduce potential climate change consequences. In many metropolitan areas, cities are experiencing a “heat island” effect—the phenomenon where an urban area becomes much warmer than the land around it.<sup>31</sup> Heat islands are caused by development, impermeable paved surfaces replace vegetation and open land, while vehicles and buildings produce waste heat and reflect sunlight, preventing the urban area from cooling off as efficiently as its surroundings.<sup>32</sup> In Makati City in the Philippines, three thousand trees are planted each year to reduce pollution and this urban heat island effect, as well as to reabsorb carbon dioxide.<sup>33</sup> A similar initiative was implemented in the United Kingdom in Greater Manchester to promote green roofing, resulting in significant temperature decreases in town centers.<sup>34</sup> Finally, in Bogotá, city officials devised a creative solution to the Doña Juana landfill, which had plagued the city with gases that contributed to global warming, air pollution, and public health concerns.<sup>35</sup> By installing a vapor drainage system that collects gases produced by the landfill, Bogotá engineers

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[<https://perma.cc/T7YU-Y7T3>] (archived Oct. 26, 2019) [hereinafter WBUR Article] (discussing the actions of major cities to combat the effects of rising sea levels).

27. *Id.*

28. *Id.*

29. *Id.*

30. *Id.*

31. *Heat Islands*, U.S. ENVTL. PROT. AGENCY (Jan. 11, 2017), <https://www.epa.gov/heat-islands/learn-about-heat-islands> [<https://perma.cc/EC29-9NEU>] (archived Oct. 26, 2019) [hereinafter *Heat Islands*].

32. *Id.*

33. THE WORLD BANK, SUSTAINABLE LOW-CARBON CITY DEVELOPMENT IN CHINA 25 (Alex Bäumler et al. eds., 2012) [hereinafter BAEÜMLER WORLD BANK].

34. See generally S.E. Gill et al., *Adapting Cities for Climate Change: The Role of the Green Infrastructure*, 33 BUILT ENV’T 115, 121–23 (2007).

35. Martinez, *supra* note 21.

are now able to convert and divert the gases to be used for more sustainable energy production.<sup>36</sup>

Some particularly effective programs help cities both mitigate and adapt to the impacts of climate change. For example, in Dar Es Salaam in Tanzania, the Tanzanian government implemented a marine and coastal conservation project that included planting thousands of mangroves along the coastline.<sup>37</sup> This vegetation has several purposes: it prevents beach erosion and protects the city from storm surges, but it also helps reabsorb carbon dioxide.<sup>38</sup> This reabsorption plays a role in reducing the emissions that lead to global warming and more extreme tropical storms in the first place.<sup>39</sup> Similarly, in Lviv, Ukraine, the city implemented a program to outfit its buildings with energy efficient infrastructure and appliances.<sup>40</sup> This adaptation not only makes buildings better able to withstand the extreme temperatures and weather events that come with climate change but it also reduces their energy consumption and, therefore, the city's carbon footprint.<sup>41</sup>

Adaptation efforts are going to be crucial to mankind's ability to prepare for and survive the consequences of climate change that have become inevitable.<sup>42</sup> Two major barriers to the widespread implementation of these measures is that they must fit within the environmental regulatory schemes each nation has in place on both local and national levels, and they must be funded, either federally or locally. While federal environmental policy in the United States is largely governed by major policies like the Clean Air Act, Clean Water Act, and the Endangered Species Act, much of the adaptation work is done on the state or local level, both funded and implemented by municipal governments.<sup>43</sup> These local efforts tend not to be preempted by federal legislation, but must still meet federal requirements in order to obtain the necessary permits and qualify for federal funding.<sup>44</sup> Environmental policies for many European nations are primarily shaped by and must comply with the European Union's environmental framework.<sup>45</sup> Adaptation programs in Europe and Asia may be

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36. *Id.*

37. BAEUMLER WORLD BANK, *supra* note 33, at 25.

38. *Id.*

39. *Id.*

40. *Id.*

41. *Id.*

42. *See How Do People Adapt to Climate Change?*, EUR. ENVTL. AGENCY, <https://www.eea.europa.eu/themes/climate/faq/how-do-people-adapt-to-climate-change> (last visited Oct. 13, 2019) [<https://perma.cc/DBY6-4A49>] (archived Oct. 26, 2019) (discussing climate change, vulnerable populations, and adaption and mitigation steps).

43. *See infra* Part III.A.3.

44. Lawrence H. Goulder & Robert N. Stavins, *Interactions Between State and Federal Climate Change Policies* 1 (Mossavar-Rahmani Ctr. for Bus. & Gov't, Working Paper No. 2010-08, 2010), <https://www.nber.org/papers/w16123.pdf> [<https://perma.cc/5WH2-5VCG>] (archived Oct. 26, 2019).

45. *Tracking climate policies in European Union countries*, EUR. ENVTL. AGENCY (July 5, 2018), <https://www.eea.europa.eu/themes/climate/national-policies-and->

designed by local authorities or implemented on the municipal level, but they typically receive federal funding.<sup>46</sup>

While the vast majority of adaptation measures are implemented on a local level, many are funded by municipalities as well. Local governments can utilize a variety of ways to raise capital for projects, including taxes, fees, bonds, loans, and public–private partnerships that enable public agencies and private sector entities like corporations to collaborate in the “financing, planning, design, construction, and maintenance of [sustainable] infrastructures.”<sup>47</sup> Each of these mechanisms comes with its advantages and disadvantages. For example, public–private partnerships enable municipalities to meet public service needs while reducing the costs of construction and maintenance, accelerating implementation, and shifting performance risks to the private partner.<sup>48</sup> On the other hand, this opens the door for transparency and accountability issues and shifts control of the project from the municipality to the partner.<sup>49</sup>

### III. ANALYSIS

Just as the issues each nation faces in a warming world vary, so too does the effectiveness of their attempts at adaptation. This Part will analyze the effectiveness of coastal cities’ climate change adaptation mechanisms, using South Florida, Venice, and the Philippines as case studies. For each, this Part will first outline the regulatory framework in place in each country, followed by the challenges posed to it by rising sea levels. Next, it will expound upon the adaptation strategies each city or region has implemented, including whether each of these mechanisms is funded federally or locally. Finally, it will evaluate the relative successes and failures of each country’s attempts to adapt.

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measures/tracking-climate-policies-in-european#tab-related-briefings  
[<https://perma.cc/9W38-N8EZ>] (archived Oct. 26, 2019).

46. *Laws & Regulations*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/laws-regulations> (last visited Oct. 29, 2018) [<https://perma.cc/6L8M-2TCR>] (archived Oct. 26, 2019).

47. *Federal Funding and Technical Assistance for Climate Change Adaptation*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/arc-x/federal-funding-and-technical-assistance-climate-adaptation> (last visited Oct. 29, 2018) [<https://perma.cc/EPL8-N2WA>] (archived Oct. 26, 2019).

48. *Getting to Green: Paying for Green Infrastructure*, U.S. ENVTL. PROT. AGENCY, [https://www.epa.gov/sites/production/files/2015-02/documents/gi\\_financing\\_options\\_12-2014\\_4.pdf](https://www.epa.gov/sites/production/files/2015-02/documents/gi_financing_options_12-2014_4.pdf) (last visited Oct. 29, 2018) [<https://perma.cc/L7PQ-8UNU>] (archived Oct. 26, 2019).

49. *Id.*



### A. United States: Miami and South Florida

Although sea level rise puts much of the United States' East Coast at risk of flooding, many of the nation's most vulnerable cities line the southern tip of Florida.<sup>50</sup> The Miami metropolitan area is one of these cities.<sup>51</sup>

#### 1. United States' Regulatory Scheme

The cities of Miami and Fort Lauderdale, which make up most of the metropolitan area commonly referred to as South Florida, are situated on the southernmost edge of the state's Atlantic coast.<sup>52</sup> The manner in which these cities' adaptation programs fit into the nation's larger regulatory scheme is relatively straightforward. At the federal level, major environmental laws in the United States are interpreted and enforced through regulations created by the Environmental Protection Agency (EPA), the U.S. Department of the Interior, and the U.S. Army Corps of Engineers (Corps).<sup>53</sup> However, many of these statutes delegate the responsibility to actually implement these federal laws to state environmental agencies.<sup>54</sup> State governments are free to pass their own legislation and regulations, which may be stricter than federal laws, unless specifically preempted by a corresponding federal law.<sup>55</sup> Similarly, local governments can also adopt more stringent legislation, unless it conflicts with either state or federal laws.<sup>56</sup>

The most notable pieces of federal legislation governing the nation's environment include the Clean Water Act (CWA); the Endangered Species Act (ESA); the Safe Drinking Water Act (SDWA); and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).<sup>57</sup> The CWA regulates pollutants that are discharged into any United States body of water; responsibility for its execution is split between the EPA, Corps, and individual states.<sup>58</sup> The ESA governs the conservation and recovery of endangered species and their habitats across the nation, while the SDWA, as its name implies,

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50. See Carolyn Kormann, *Miami Faces An Underwater Future*, NEW YORKER (July 3, 2018), <https://www.newyorker.com/news/news-desk/miami-faces-an-underwater-future> [<https://perma.cc/GQC6-5EZW>] (archived Oct. 26, 2019) (discussing the economic effects of rising seawaters).

51. *Id.*

52. Charles Rabin, *South Florida Population Hits 6 Million for First Time*, MIAMI HERALD (Mar. 24, 2016), <https://www.miamiherald.com/news/local/article68048512.html> [<https://perma.cc/Q3BE-JLQR>] (archived Nov. 3, 2019).

53. David Y. Chung, *Environmental Law and Practice in the United States: Overview*, REUTERS, Oct. 17, 2017, at 7.

54. *Id.* at 8.

55. *Id.* at 3.

56. *Id.*

57. *Id.*

58. *Id.*

regulates all public drinking water supplies.<sup>59</sup> Finally, CERCLA regulates the cleanup of sites, spills, and accidents involving hazardous substances.<sup>60</sup> It imposes strict liability on owners and operators of the land on which these events occur.<sup>61</sup>

While these statutes have an enormous impact on conservation, development, and industry across the nation, they generally leave room for more state and local action rather than preempting it.<sup>62</sup> This allows South Florida's municipal bodies to act as they see fit, implementing adaptation programs at a local level. However, if they require federal funding or federal permitting, these programs must comply with all federal requirements.<sup>63</sup> One of the most notable of these is section 7 of the ESA, which requires any federal agency that carries out, funds, or authorizes an action to first consult with the Secretary of the Interior to ensure it does not jeopardize the existence of an endangered species or adversely modify its habitat.<sup>64</sup> Similarly, the National Environmental Policy Act (NEPA) requires all federal agencies (or state or local agencies implementing projects that receive federal funding or permits) to evaluate the possible environmental effects their projects may have.<sup>65</sup> Under the act, these agencies must first prepare an Environmental Assessment (EA), a preliminary evaluation that determines whether the program will significantly impact the environment.<sup>66</sup> If the answer to an EA is affirmative, the agency must then prepare an Environmental Impact Statement (EIS), which requires them to describe the projected impact their program will have on the environment and natural resources, and include possible alternatives to the proposed program.<sup>67</sup> While NEPA's requirements are procedural rather than substantive, and agencies can proceed with projects even if an EIS projects serious environmental effects, it mandates that agencies conduct at least enough research to

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59. *Id.* at 4.

60. *Id.*

61. *Id.*

62. *Id.*

63. Olivia Bensinger, *Endangered Species Act to the Rescue? Climate Change Mitigation and Adaptation Under the ESA*, VT. J. ENVTL. L., <http://vjel.vermontlaw.edu/endangered-species-act-rescue-climate-change-mitigation-adaptation-esa/> (last visited Oct. 25, 2019) [<https://perma.cc/MDB9-QGDE>] (archived Oct. 26, 2019); Jennifer Klein & Ethan Strell, *Legal Tools for Climate Adaptation Advocacy: NEPA*, COLUM. LAW SCH.: SABIN CTR. FOR CLIMATE CHANGE LAW 1–3 (Mar. 2015), <http://columbiaclimatelaw.com/files/2016/06/Klein-and-Strell-2015-03-Adaptation-Avocacy-NEPA.pdf> [<https://perma.cc/5LMA-PUPD>] (archived Nov. 9, 2019); *Section 404 Permit Program*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/cwa-404/section-404-permit-program> (last visited Feb. 28, 2019) [<https://perma.cc/S9KC-CMEZ>] (archived Oct. 26, 2019) [hereinafter *Section 404 Permit Program*].

64. Bensinger, *supra* note 63.

65. Klein & Strell, *supra* note 63.

66. *See id.*

67. *See id.*

make informed decisions.<sup>68</sup> Finally, section 404 of the CWA regulates all activities that involve discharging dredged materials into US waters; implicated activities include everything from the construction of dams and levees, to infrastructure development like highways and airports, to filling in wetland areas for development.<sup>69</sup> While some adaptation mechanisms are oriented toward protecting wetlands and coastal ecosystems, other infrastructural projects, like building levees or elevating roadways, may have environmental effects that trigger evaluation under these federal statutes.<sup>70</sup> Agencies at all governmental levels will need to ensure that they comply with these permitting requirements in order to implement many types of adaptation mechanisms.

## 2. Challenges Posed by Sea Level Rise

Thanks to its low elevation, South Florida faces a myriad of concerns as water rises around it.<sup>71</sup> By 2045, over a fifth of the region is projected to be underwater at high tide, based on the current rate of global warming.<sup>72</sup> More frequently than ever, floods cause temporary business closures, hinder commuters heading to work and school, force residents to abandon their homes, and cause sewers and canals to overflow, which poses serious health threats.<sup>73</sup> These growing dangers have resulted in what some researchers have coined “climate gentrification”; as wealthier residents flee coastal neighborhoods and seek higher ground, the low-income communities that have historically lived in the elevated city center are being forced out by rising property values.<sup>74</sup> Although climate scientists’ forecasts for the region are only getting grimmer, construction has not slowed in these at-risk areas.<sup>75</sup> In a July 2019 study, scientists analyzed the total number of homes that would be at risk of a ten-year flood by 2100 and found that Florida would have by far the most in the nation: 1.58 million properties.<sup>76</sup> Nearly twenty thousand of those homes have been built in the last decade, in spite of risk projections.<sup>77</sup>

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68. *See id.*

69. *Section 404 Permit Program, supra* note 63.

70. *Id.*

71. Kormann, *supra* note 50.

72. *Id.*

73. *Id.*

74. *Id.*

75. Climate Central, *802,555 Homes at Risk of 10-Year Flood Inundation by 2100*, ZILLOW (July 31, 2019), <https://www.zillow.com/research/homes-at-risk-coastal-flooding-25040/> [<https://perma.cc/9CPC-YVNJ>] (archived Oct. 27, 2019).

76. *Id.*

77. *Id.*

### 3. Adaptation Programs

As the sense of urgency has grown in these Floridian communities, so too has the pressure they have exerted on their local governments to do more to adapt. The results are already visible. Miami's Department of Water and Sewer has committed to spending \$13 billion on infrastructural upgrades over the next two decades, starting with an overhaul of the Central District Wastewater and Treatment Plant located on Virginia Key.<sup>78</sup> Engineers have redesigned new buildings in the facility to be raised substantially above the projected future sea level height, ensuring that the plant will stay operational even during storm surges, and protecting the surrounding community from the health hazards that a shutdown or overflow could cause.<sup>79</sup> In the city of Miami Beach alone, over one hundred miles of major roadways are being raised as well.<sup>80</sup> Floodgates have been erected in shopping malls, hundreds of seawalls are being raised and repaired, and a collection of tidal valves—mechanisms that only allow water to flow one way into drains and pipes to prevent floodwaters from backflowing out—are being installed in drainage systems throughout the region.<sup>81</sup> Miami has changed its construction codes, requiring that all new buildings have elevated first floors, and adopted a \$400 million integrated pumping system to help control flooding.<sup>82</sup> In 2014, the city constructed a 4,200 foot tunnel that stretches from the Port of Miami to I-395, which is equipped with floodgates that will seal off both ends in the event of a hurricane.<sup>83</sup> Finally, the city of Miami Beach has constructed "Living Shorelines," which are projects that utilize organic materials like indigenous wetland plants, submerged vegetation, logs, sand, and stone to stabilize shoreline banks.<sup>84</sup> These Living Shorelines protect the banks they are installed on from erosion, create natural habitats for fish and plants, and protect surrounding areas from storm surges.<sup>85</sup>

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78. James Murley, *Miami-Dade Walking the Walk on Resilience*, MEDIUM (Sept. 21, 2017), <https://medium.com/cityspeak/miami-dade-walking-the-walk-on-resilience-7bc05628e11a> [https://perma.cc/55AB-FKWS] (archived Oct. 27, 2019).

79. *Id.*

80. Amanda Ruggeri, *Miami's Fight Against Rising Seas*, BRIT. BROAD. CORP. (Apr. 3, 2017), <http://www.bbc.com/future/story/20170403-miamis-fight-against-sea-level-rise> [https://perma.cc/2QAY-QDNT] (archived Nov. 9, 2019).

81. *Id.*

82. *Id.*

83. *Id.*

84. *Living Shorelines*, MIAMI BEACH RISING ABOVE, <http://www.mbrisingabove.com/climate-adaptation/green-infrastructure/living-shorelines/> (last visited Feb. 28, 2019) [https://perma.cc/AJ2T-LC5J] (archived Oct. 27, 2019).

85. *Id.*

#### 4. Source of Funding

Miami's efforts to adapt to sea level rise are some of the most progressive and innovative in the country. But, where is the funding for all of these adaptation projects coming from? In South Florida, at least, taxpayers shoulder the brunt of the financial costs of climate change adaptation.<sup>86</sup>

While there are several federal sources of funding, accepting these funds may put states at the whim of the federal government, where the political climate is not always predictable.<sup>87</sup> Communities afflicted by sea level rise can obtain financial aid from these federal sources, in the form of either *ex ante* protection or *ex post* relief.<sup>88</sup> The Federal Emergency Management Agency (FEMA) oversees the Hazard Mitigation Grant Program (HMGP) and the Disaster Relief Fund, which provide up to 75 percent of funding for adaptive programs or relief from federally declared disasters, respectively.<sup>89</sup> As the frequency of hurricanes, floods, and other climate change-related disasters has increased, however, so has the strain on FEMA's funding capacity.<sup>90</sup> In 2017, for example, as Hurricane Irma raged toward the Floridian coastline, FEMA's Disaster Relief Fund had just \$1 billion left—ostensibly a large sum of money, but less than 2 percent of what FEMA provided East Coast states after Hurricane Sandy battered the region in 2012.<sup>91</sup> This should encourage the federal government to

86. See Urban Resilience Project, *Making the "Miami Forever Bond" a Model for Equitable Climate Adaptation*, MEDIUM (Oct. 22, 2018), <https://medium.com/@UrbanResilience/making-the-miami-forever-bond-a-model-for-equitable-climate-adaptation-c4826b4b209c> [<https://perma.cc/SV79-HZG4>] (archived Oct. 27, 2019) (discussing progressive measures taken by the City of Miami to combat flooding).

87. See Mary Scott Nabors, *US Government Shutdown Halts Federal Funding for Critical Rebuilding Program*, BORN2INVEST (Jan. 18, 2019), <https://born2invest.com/articles/us-government-shutdown-halts-federal-funding-critical-rebuilding-needs/> [<https://perma.cc/7LSX-V4JV>] (archived Oct. 27, 2019) (discussing the need for disbursement of federal aid to cities in order to take precautionary measures for rising sea level).

88. Severn Gourley, Note, *Funding Adaptation: Financing Resiliency Through Sea Level Derivatives*, HARV. ENVTL. L. REV. (Apr. 17, 2017), <https://harvardelr.com/2017/04/17/funding-adaptation-financing-resiliency-through-sea-level-derivatives/> [<https://perma.cc/H62Z-M3MR>] (archived Nov. 9, 2019).

89. *Hazard Mitigation Grant Program*, FED. EMERGENCY MGMT. AGENCY, <https://www.fema.gov/hazard-mitigation-grant-program> (last visited Jan. 18, 2019) [<https://perma.cc/2S65-7EX2>] (archived Oct. 27, 2019).

90. See *Public Assistance: Local, State, Tribal, Private, and Non-Profit*, FED. EMERGENCY MGMT. AGENCY, <https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit> (last visited Jan. 18, 2019) [<https://perma.cc/72DG-GGB4>] (archived Oct. 27, 2019).

91. See *More Than \$1 Billion in FEMA Funds Approved to Reimburse Hurricane Irma Infrastructure Costs in Florida*, FED. EMERGENCY MGMT. AGENCY (July 11, 2019), <https://www.fema.gov/news-release/2019/07/11/more-1-billion-fema-funds-approved-reimburse-hurricane-irma-infrastructure> [<https://perma.cc/Y94H-RHBH>] (archived Nov. 3, 2019); Daniel J. Weiss et al., *Disastrous Spending: Federal Disaster-Relief*

spend smarter and invest more in HMGP; every dollar spent on adaptation is projected to save an average of \$4 in disaster relief.<sup>92</sup>

An important drawback of HGMP funding is that cities receiving it are put at the mercy of the federal government, and therefore these cities are subject to the volatility of the current political climate.<sup>93</sup> The record-breaking government shutdown of January 2019, for example, brought funding to a halt in New Orleans, where the HGMP has allocated \$150 million for a variety of projects aimed at improving the city's water retention and minimizing flooding.<sup>94</sup> Until the government reopened and funds became accessible again, progress on green infrastructure projects in New Orleans had to be put on hold.<sup>95</sup> Given that Florida receives these federal HGMP funds, the state is similarly at the mercy of political whims.

A second source of federal funding for adaptation programs is the Flood Mitigation Assistance Grant Program (FMA), another subprogram of FEMA, and perhaps the most specifically applicable to communities facing sea level rise.<sup>96</sup> The FMA program aims to provide federal funding to states and communities who implement projects that reduce or eliminate their long-term risk of flood damage to facilities insured by the National Flood Insurance Program (NFIP), which is an affordable flood insurance program run by the federal government.<sup>97</sup> The goal of the FMA is similar to that of the HGMP—to reduce the federal government's claims and payouts under the NFIP by encouraging communities to mitigate their risk of flooding in the first place.<sup>98</sup>

While the federal government approved a \$550 million HMGP grant for Florida in February of 2018, as of late 2019, the money had not been disbursed.<sup>99</sup> Texas Land Commissioner George P. Bush, whose state was also earmarked to receive HMGA funding, complained in January 2019 that the Trump administration still had not issued

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*Expenditures Rise Amid More Extreme Weather*, CTR. AM. PROGRESS (Apr. 29, 2013), <https://www.americanprogress.org/issues/green/reports/2013/04/29/61633/disaster-spending-federal-disaster-relief-expenditures-rise-amid-more-extreme-weather/> [<https://perma.cc/98JJ-ANMK>] (archived Oct. 27, 2019) (discussing \$136 billion in federal funding provided for disaster relief after hurricane Sandy).

92. Gourley, *supra* note 88.

93. Beau Evans, *Shutdown Could Slow New Orleans Green Infrastructure Work*, TIMES-PICAYUNE (Jan. 17, 2019), <https://www.nola.com/politics/2019/01/shutdown-could-slow-new-orleans-green-infrastructure-work.html> [<https://perma.cc/Z8HJ-R5JP>] (archived Oct. 27, 2019).

94. *Id.*

95. *Id.*

96. *See Flood Mitigation Assistance Grant Program*, FED. EMERGENCY MGMT. AGENCY, <https://www.fema.gov/flood-mitigation-assistance-grant-program> (last visited Jan. 18, 2019) [<https://perma.cc/S5SE-4X2V>] (archived Oct. 27, 2019) (providing background on the Flood Mitigation Assistance Grant Program).

97. *Id.*

98. *Id.*

99. Nabors, *supra* note 87.

rules indicating how the recipient states can even apply for this money.<sup>100</sup> Another source indicated that President Trump explored the possibility of reallocating these funds to build a border wall given Congress's failure to fund it.<sup>101</sup> And because the state of Florida's administration has denied the existence of climate change for the last eight years (former Governor Rick Scott went so far as to "prohibit his agencies from even using the terms 'climate change' and 'global warming' in official documents"), state funding is unlikely to be imminent.<sup>102</sup>

Instead, municipal and county governments have had to take matters into their own hands.<sup>103</sup> In 2007, the city of Miami partnered with the Florida Department of Transportation, the Miami-Dade County government, and private contractor MAT Concessionaire, LLC to create a public-private partnership for the funding, construction, and maintenance of the Port of Miami Tunnel detailed above.<sup>104</sup> In 2017, voters in the city of Miami passed a \$400 million bond (the "Miami Forever Bond").<sup>105</sup> The funds will be allocated to the myriad of flood-proofing mechanisms listed above—pumps, drains, seawalls, and more.<sup>106</sup> In order to pay off the bond, however, the city will levy a new property tax on residents, effectively shifting the cost to homeowners.<sup>107</sup>

South Floridian lawmakers must balance competing interests when it comes to new development in low elevation areas. On one hand, since the state does not have a personal or corporate income tax, property taxes are essential to state revenue—making development highly desirable.<sup>108</sup> On the other hand, every new building that is constructed without any adaptation mechanisms adds to the future costs the state will incur as the sea level rises.<sup>109</sup> When properties are swallowed by rising tides, so are the property taxes the state could previously collect on them.<sup>110</sup> New development that is not flood resistant "expands Florida's vulnerability and increases the magnitude

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100. *Id.*

101. *Id.*

102. See Emanuela Molinaroli et al., *How Venice and Miami are Adapting to Sea-Level Rise*, MARXIV, <https://www.marxivinfo.org/summary/how-venice-and-miami-are-adapting-sea-level-rise> (last updated May 2018) [<https://perma.cc/4B9X-KUEA>] (archived Oct. 27, 2019) (discussing the impact of political changes to Miami's climate change relief plan).

103. *See id.*

104. *See Project Overview, PORT MIAMI TUNNEL*, <http://www.portofmiamitunnel.com/project-overview/project-overview-1/> (last visited Feb. 29, 2019) [<https://perma.cc/JLT3-D836>] (archived Oct. 27, 2019) (describing the PortMiami Tunnel project).

105. Urban Resilience Project, *supra* note 86.

106. *Id.*

107. *Id.*

108. Ruggeri, *supra* note 80.

109. *Id.*

110. *Id.*

of its risk.”<sup>111</sup> Currently, the need for adaptation program funding outweighs this expansion of risk, justifying the rapid increase of development in the region.

It may seem like the financial burden of these programs could be shifted elsewhere—to developers, perhaps—but there are practical difficulties associated with imposing the cost of adaptation measures on private developers. Investors typically have short-term interests, considering only the costs and practicalities associated with a property between construction and sale.<sup>112</sup> They have little incentive to consider possible problems from sea level rise that may not occur for decades, and even less incentive to make costly adjustments to their infrastructure in anticipation of these challenges.<sup>113</sup> In order to force developers to shoulder some of the costs of adaptation, municipalities should update their zoning and building codes to require new structures to be flood resistant.<sup>114</sup> This can be done via minimum seawall height requirements, elevated first floors, and requiring backwater valves to protect sewage lines.<sup>115</sup>

Finally, the size, geology and resources of a community also have an impact on who will—or even can—bear the burden of paying to protect a city.<sup>116</sup> While property taxes are an excellent source of funding for infrastructural improvements in larger, metropolitan areas like South Florida, which have huge tax bases, smaller communities may struggle with this model.<sup>117</sup> Property taxes may be an even less feasible funding mechanism for small coastal communities, given that as the sea level rises and beachfront property is lost to erosion, those property values will plummet and the municipality’s tax base will shrink even more.<sup>118</sup> Smaller communities will have an inversely greater need for funding from state and federal government sources.<sup>119</sup> For South Florida, however, its tax base seems to be the most feasible source of funding for adaptation measures, given the difficulties associated with procuring financing from the federal and state governments or shifting the burden to private developers.<sup>120</sup>

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111. *Id.*

112. *Id.*

113. *Id.*

114. *Building Code Resources*, FED. EMERGENCY MGMT. AGENCY, <https://www.fema.gov/building-code-resources> (last visited Oct. 13, 2019) [<https://perma.cc/2L3M-86E2>] (archived Oct. 27, 2019) (providing examples of flood-resistant requirements in building codes).

115. *See, e.g., Design Considerations in Floodproofing*, FED. EMERGENCY MGMT. AGENCY, [https://www.fema.gov/media-library-data/643d07bceee8ade17eef8e11cf7a2abb/P-936\\_sec2\\_508.pdf](https://www.fema.gov/media-library-data/643d07bceee8ade17eef8e11cf7a2abb/P-936_sec2_508.pdf) (last visited Oct. 13, 2019) [<https://perma.cc/R6MN-D365>] (archived Oct. 27, 2019) (outlining some design considerations for floodproofing).

116. *Id.*

117. *Id.*

118. *Id.*

119. *Id.*

120. *See generally Who Will Pay for the Huge Costs of Holding Back Rising Seas?*, YALE SCH. FORESTRY & ENVTL. STUD., <https://e360.yale.edu/features/who-will-pay-for->



### B. Italy: Venice

Venice, like Miami, has been identified as one of the most vulnerable cities in the world when it comes to sea level rise.<sup>121</sup> The city, regarded as one of the greatest artistic, cultural, and historic sites in the world, was built more than sixteen-hundred years ago on what began as a series of dozens of muddy islets.<sup>122</sup> The Veneti people fled to them in order to seek shelter from pillaging invaders, and, within decades, a city was born.<sup>123</sup> While Venice has never had a stable tectonic foundation, it is now simultaneously sinking while the Venetian Lagoon rises around it, putting all its historic and artistic masterpieces in jeopardy.<sup>124</sup> Artist Lorenzo Quinn captured the city's collective sense of fear in his 2017 sculpture *Support*: two enormous plaster hands reaching up, out of the turquoise waters of the Grand Canal and grasping desperately at the walls of the Ca' Sagredo Hotel.<sup>125</sup>

#### 1. Regulatory Scheme

Italy's environmental regulatory scheme, like many other European nations, is largely dominated by environmental legislation of the European Union (EU), which member states are then individually responsible for implementing and enforcing.<sup>126</sup> The statute at the heart of all environmental regulation is Legislative Decree 152/2006 (the Environmental Protection Code), which outlines major principles—derived from the EU—for protecting Italy's environment.<sup>127</sup> The Environmental Protection Code encompasses all environmental matters, governing everything from air quality to soil

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the-huge-costs-of-holding-back-rising-seas (last visited Oct. 13, 2019) [https://perma.cc/ER9C-R7MC] (archived Oct. 27, 2019) (discussing tax implications of rising seawaters).

121. Molinaroli et al., *supra* note 102.

122. See Hans-Jurgen Schlamp, *Venice's Eternal Battle Against Water*, SPIEGEL ONLINE (June 12, 2012), <http://www.spiegel.de/international/europe/venice-s-struggle-against-the-water-a-838713.html> [https://perma.cc/359Y-539H] (archived Oct. 27, 2019) (describing life in Venice during *acqua alta*).

123. *Id.*

124. *Id.*

125. See *The Two Hands that Emerge from the Water to Denounce Climate Change are Amongst the Most Discussed Works of the Venice Biennale 2017*, VICE (May 16, 2017), <https://www.vice.com/it/article/ae5ypk/abbiamo-intervistato-lartista-dietro-le-manigiganti-sul-canal-grande> [https://perma.cc/FTQ3-XMWY] (archived Oct. 27, 2019) (featuring a photo of Lorenzo Quinn's sculpture).

126. See *Implementation of Community Environmental Legislation*, EUR. COMM'N, [http://ec.europa.eu/environment/legal/implementation\\_en.htm](http://ec.europa.eu/environment/legal/implementation_en.htm) (last visited Jan. 18, 2019) [https://perma.cc/S53S-BXHC] (archived Oct. 27, 2019) (discussing regulatory relationship between EU and member states).

127. Mara Chilosi et al., *Environmental Law and Practice in Italy: Overview*, REUTERS, Jan. 2, 2017, at 2.

protection to waste and packaging management.<sup>128</sup> Member states are free to pass legislation that is more stringent than the EU's, so long as it meets all of the standards set by the EU.<sup>129</sup> In a similar multilevel governance structure to the United States, the Italian state is the dominant regulatory authority, but individual regions are allowed to maintain control of some environmental enforcement in their territories.<sup>130</sup> These regions and the smaller municipalities within them are also free to pass protective measures, so long as they are stricter than the standards set by the levels of government above them.<sup>131</sup>

The responsibility and authority to intervene in the Venetian Lagoon fits into this regulatory framework as follows: the Italian state is responsible for measures to “physically safeguard the lagoon and restore hydro-geological balance”; the Veneto regional government is responsible for regulating water pollution; and the Venetian metropolitan government is responsible for “urban restoration and maintenance,” as well as monitoring socioeconomic growth.<sup>132</sup> Metropolitan Venice itself is further divided into six townships with their own councils and presidents; the Lagoon region is comprised of Venezia (the historic city and the islands of Murano and Burano) and Lido-Pellestrina (the barrier islands).<sup>133</sup> These governmental bodies' authorities overlap, which has led to a lack of coordination in managing the Lagoon.<sup>134</sup> However, both the national and regional governments have delegated control over research, development, and implementation of protective measures in the Lagoon to the Consorzio Venezia Nuova (CVN), a collection of the nation's leading industrial companies and engineering firms.<sup>135</sup> The CVN developed a “General Plan of Intervention” in the Venetian Lagoon, which is a comprehensive system of environmental reforms that aim to defend the Lagoon from high waters and severe storms, to reverse the erosion of the Lagoon basin, and to restore damaged ecosystems there.<sup>136</sup> MOSE is the most significant component of this plan.<sup>137</sup>

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128. *Id.*

129. *Id.* at 3.

130. *Id.*

131. *Id.*

132. Dimitri D. Deheyn & Lisa R. Schaffer, *Saving Venice: Engineering and Ecology in the Venice Lagoon*, U.C. SAN DIEGO SUSTAINABILITY SOLS. INST. PUBL'N SERIES 8 (2007), <https://escholarship.org/content/qt4tv2s434/qt4tv2s434.pdf> [https://perma.cc/9Y5S-TCBF] (archived Oct. 27, 2019).

133. *Venice and its Lagoon*, MINISTRY OF CULTURAL HERITAGE & ACTIVITIES & TOURISM, [http://www.veniceandlagoon.net/web/en/steering\\_committee/municipality\\_venice/](http://www.veniceandlagoon.net/web/en/steering_committee/municipality_venice/) (last visited Feb. 8, 2019) [https://perma.cc/C9SJ-HXW5] (archived Oct. 27, 2019).

134. Molinaroli et al., *supra* note 102, at 1.

135. *Id.*

136. Deheyn & Schaffer, *supra* note 132.

137. *Id.*

## 2. Challenges Posed by Sea Level Rise

As described above, Venice faces a unique challenge: the island itself is sinking, and at the same time, the body of water around it is rising.<sup>138</sup> “*Acqua alta*,” or high water, is nothing new to Venetians; it has been a fact of life since the city was erected in the middle of the Venetian Lagoon.<sup>139</sup> Multiple times a year, locals could expect Piazza San Marco and other low-lying areas to be submerged by storm surges and “king tides”—the highest tide possible, caused by the gravitational forces of the Earth, moon, and sun when they are in a particular alignment.<sup>140</sup> But over the last century, these *acqua alta* events have been occurring more and more frequently, in part due to climate change, which has caused the Adriatic Sea and Venetian Lagoon to rise five and a half inches over the last century.<sup>141</sup> Simultaneously, the city has also been settling, a result of years of groundwater being pumped out from beneath the city, as well as the accumulating weight of its buildings, which has compressed the island itself.<sup>142</sup> The results of this flooding have been devastating for the island and its countless historical artifacts. Experts believe that the most recent flood in 2018 damaged St. Mark’s Basilica, one of the most famous churches in the world, causing it to “age twenty years in a single day.”<sup>143</sup> More than 75 percent of the city was submerged during this same flood.<sup>144</sup> Many Venetians have raised their doors or simply abandoned their ground floors altogether, but with each flooding, the island’s businesses are forced to close, transportation becomes difficult, and tourism trickles to a stop.<sup>145</sup> Some scientists fear that Venice will be nearly uninhabitable by 2100.<sup>146</sup>

138. Interview by Christopher Livesay with Monica Chojnacka, Massima Milanese, Dario Berti, & Jane da Mosto, *Climate change challenges sinking city of Venice*, PUBLIC BROAD. SYS. (July 23, 2017), <https://www.pbs.org/newshour/show/climate-change-challenges-sinking-city-venice> [<https://perma.cc/HT84-UH7M>] (archived Nov. 3, 2019) [hereinafter Livesay PBS Interview].

139. *Id.*

140. *Id.*; see also *What is a King Tide?*, N.C. KING TIDES PROJECT, <http://nckingtides.web.unc.edu/king-tide/> (last visited Jan. 18, 2019) [<https://perma.cc/S88J-PVFX>] (archived Oct. 26, 2019).

141. Livesay PBS Interview, *supra* note 138.

142. *Venice Menace: Famed City is Sinking and Tilting*, LIVESCIENCE (Mar. 21, 2012), <https://www.livescience.com/19195-venice-sinking-slowly.html> [<https://perma.cc/C26K-GSGN>] (archived Oct. 27, 2019).

143. Lauren Smith-Spark et al., *Venice Floods: Warnings Salt Water Could Damage Artifacts*, CNN (Nov. 1, 2018), <https://www.cnn.com/2018/10/31/europe/italy-venice-flooding-intl/index.html> [<https://perma.cc/D2ZF-SXFK>] (archived Oct. 27, 2019).

144. *Id.*

145. See generally Livesay PBS Interview, *supra* note 138 (commenting on how tourism contributes to problems in Venice).

146. Carl Amos et al., *Venice Flooding is Getting Worse*, THE CONVERSATION (Nov. 12, 2018), <https://theconversation.com/venice-flooding-is-getting-worse-and-the-citys-grand-plan-wont-save-it-106197> [<https://perma.cc/T2SZ-RQHA>] (archived Oct. 27, 2019).

The challenges Venice faces extend beyond the island itself. Pollution from the region's industry, coastal development, and tourism have destroyed the natural mudflats that historically allowed the Venetian Lagoon to better absorb flood waters.<sup>147</sup> Native birds, fish, and mammals have disappeared, and with them the grasses, trees, and shrubs that previously secured sand dunes.<sup>148</sup> These dunes in turn helped shield the Venetian Lagoon from the brunt of extreme weather events.<sup>149</sup> The health of the entire coastal region is now at stake.<sup>150</sup>

### 3. Adaptation Programs

The devastating floods of 1966, which submerged the city of Venice under more than a meter of water, spurred the Italian government to begin to act.<sup>151</sup> The Italian Parliament passed its so-called Special Law for Venice (Special Law 171) in 1973, a bill that deemed the safety of Venice and the surrounding Venetian Lagoon "a problem of the highest national interest."<sup>152</sup> Special Law 171, which has been expanded and refinanced in the decades since, identifies six areas for the government to target with intervention projects.<sup>153</sup> These include sewage and water treatment projects to reduce industrial pollution in the Venetian Lagoon, projects to purify and restore the natural flow of rivers in the area, plans to reduce or divert waste from agricultural and livestock byproducts from the Venetian Lagoon, and, finally, projects to monitor any environmental issues in the region and implement experimental programs to combat them.<sup>154</sup> This last area is where the MOSE project fits into Venice's legal environmental framework. The gates are being constructed on an experimental basis to test whether or not the Venetian Lagoon can be protected from the

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147. James McGregor, *What Venice Can Teach American Cities*, ATLANTIC (Dec. 4, 2018), <https://www.theatlantic.com/technology/archive/2018/12/what-us-cities-can-learn-from-venices-floods/577255/> [<https://perma.cc/B7PF-LE3C>] (archived Oct. 27, 2019).

148. *See id.* (describing how the replanting of grasses, trees, and shrubs has helped to secure repaired dunes in the Lagoon surrounding Venice).

149. *Id.*

150. McGregor, *supra* note 147.

151. Marco Casagrande, *Heritage, Tourism, and Demography in the Island City of Venice: Depopulation and Heritagisation*, ISLAND DYNAMICS: URB. ISLAND STUD. 127 (2016), <http://www.urbanislandstudies.org/UIS-2-Casagrande-Venice-Heritage-Tourism-Demography.pdf> [<https://perma.cc/TL8G-V39A>] (archived Oct. 27, 2019).

152. *Id.*

153. *Special Law for Venice*, VENICE PROJECT, <http://www.veniceproject.com/index.php/en/governance/special-law-for-venice> (last visited Dec. 30, 2018) [<https://perma.cc/6TC3-8K76>] (archived Oct. 27, 2019).

154. *Id.*

type of storm surge that ravaged the island in 1966,<sup>155</sup> and again, just recently, in October 2018.<sup>156</sup>

MOSE is not the only ecological experiment that the Special Law 171 has authorized; this federal funding has permitted Venice and the surrounding Venetian Lagoon to transform into something of an environmental engineering “laboratory.”<sup>157</sup> Venice’s climate change adaptation strategy has four layers, each with numerous engineering and restoration projects within it.<sup>158</sup> The Venetian Lagoon’s first line of defense against sea level rise and storm surge is the line of barrier islands that shield it from the Adriatic Sea.<sup>159</sup> MOSE, when completed, will seal off the three inlets where water can pass through the barrier islands into the Venetian Lagoon, constituting the second layer of protection.<sup>160</sup> The third line of defense is a collection of projects to restore the mudflats and salt marshes within the Venetian Lagoon that help it absorb high water.<sup>161</sup> The fourth includes similar projects aimed at renourishing beaches, dunes, and other types of landform restoration, which will in turn make it possible for the plant and animal life that used to inhabit them to return.<sup>162</sup>

#### 4. Source of Funding

Financing for these projects comes largely from the Italian federal government.<sup>163</sup> MOSE, which is projected to cost as much as \$7 billion by the time it is completed, has been primarily funded by an Italian loan from the European Investment Bank.<sup>164</sup> It should be noted that

155. *See generally id.* (describing the types of intervention covered by the Special Law for Venice).

156. Associated Press, *Three-quarters of Venice Flooded by Exceptional High Tide*, GUARDIAN (Oct. 29, 2018), <https://www.theguardian.com/world/2018/oct/29/venice-experiences-worst-flooding-since-2008> [<https://perma.cc/3XP6-NB7S>] (archived Oct. 27, 2019).

157. McGregor, *supra* note 147.

158. *Id.*

159. *Id.*

160. *Id.*

161. *See Salt Marshes – Protection and Restoration Using Bioengineering Techniques*, EUR. UNION, [http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n\\_proj\\_id=352&docType=pdf](http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=352&docType=pdf) (last visited Oct. 13, 2019) [<https://perma.cc/5GFT-FSE2>] (archived Oct. 27, 2019) (describing successful efforts to preserve sandbanks and fill parts of the beach where erosion is the worst); McGregor, *supra* note 147 (noting projects to restore “damaged landforms and the habitats they offer to indigenous plants and animals”).

162. *Id.*

163. *See* Marco Santarelli, *Italy: EIB Provides Second Tranche of EUR 500 Million for Venice’s MOSE System*, EUR. INV. BANK (Feb. 12, 2013), <http://www.eib.org/en/infocentre/press/releases/all/2013/2013-020-italia-bei-seconda-tranche-di-500-milioni-per-il-mose-di-venezia.htm> [<https://perma.cc/4HQZ-TJGK>] (archived Oct. 27, 2019) (outlining the terms of a 500 million euro loan granted to the Italian government for the MOSE project).

164. *Id.*

not all of this money has been used for MOSE or other related projects in the Venetian Lagoon; in 2014, the former mayor of Venice and dozens of his colleagues were arrested for corruption and charged with siphoning millions of dollars from the fund.<sup>165</sup> How Italy plans to repay this loan is unclear, but in 2011, the city approved a daily tourist tax on all visitors to the island, the revenue from which has been used to help protect and restore the city.<sup>166</sup>

### C. *The Philippines: Manila*

The Philippines is a small republic comprised of one hundred million citizens settled across thousands of islands that lie just above the equator.<sup>167</sup> Its location makes the island nation prone to earthquakes and typhoons, but it also gives the nation the capacity to support some of the richest biodiversity on the planet; the country is home to more than fifty thousand species, half of which cannot be found anywhere else in the world.<sup>168</sup> As global temperatures rise, however, the Philippines faces a future that is arguably more dire than that of the countries discussed previously; this disparity exemplifies the struggle between industrialization and sustainability that developing nations everywhere face.<sup>169</sup> Western nations industrialized with reckless abandon in the nineteenth and twentieth centuries, long before the environmental repercussions of their actions would become discernable.<sup>170</sup> Now, the devastating effects of climate change are set to be felt most acutely by nations that did the least to contribute to them.<sup>171</sup> A 2018 study found that tropical nations like the Philippines

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165. Tom Kington, *Mayor of Venice Arrested Over Alleged Bribes Related to Flood Barrier Project*, *GUARDIAN*, (June 4, 2014), <https://www.theguardian.com/world/2014/jun/04/mayor-venice-arrested-alleged-kickbacks-flood-barrier> [https://perma.cc/2FW8-W9TN] (archived Oct. 27, 2019).

166. Nick Pisa, *Venice Taxes Tourists To Fund £20m Restoration Project*, *DAILY MAIL*, <https://www.dailymail.co.uk/travel/article-2019262/Venice-tourist-tax-introduced-fund-citys-20m-restoration-project.html> (last updated July 27, 2011) [https://perma.cc/QZ6U-SYCJ] (archived Oct. 27, 2019).

167. Gregorio C. Borlaza et al., *Philippines*, *ENCYC. BRITANNICA*, <https://www.britannica.com/place/Philippines> (last updated Oct. 21, 2019) [https://perma.cc/U5RC-HNQR] (archived Oct. 27, 2019).

168. *Status of the Philippine Diversity*, *REP. PHIL. DEP'T ENV'T & NAT. RES.*, Feb. 9, 2019, <http://bmb.gov.ph/388-protection-and-conservation-of-wildlife/facts-and-figures/786-status-of-the-philippine-biodiversity>.

169. *Id.*

170. See generally *Industrial Revolution*, *HISTORY*, <https://www.history.com/topics/industrial-revolution/industrial-revolution> (last visited Feb. 9, 2019) [https://perma.cc/AK6H-ZX2N] (archived Oct. 27, 2019) (providing an overview of the history of the Industrial Revolution in the United States).

171. Chris Mooney, *The People Who'll Be Most Hurt by Climate Change Did the Least to Cause Them*, *WASH. POST* (May 2, 2018), [https://www.washingtonpost.com/news/energy-environment/wp/2018/05/02/scientists-just-showed-why-climate-change-is-enormously-unfair/?utm\\_term=.735ac2d0f8e2](https://www.washingtonpost.com/news/energy-environment/wp/2018/05/02/scientists-just-showed-why-climate-change-is-enormously-unfair/?utm_term=.735ac2d0f8e2) [https://perma.cc/GH79-LMEW] (archived Oct. 27, 2019).

are expected to suffer disproportionately more than countries that have emitted far greater amounts of greenhouse gases, like the United States and western Europe.<sup>172</sup> Even in light of this inequitable distribution of climate change consequences, developing nations still face international pressure to develop more sustainably than their developed counterparts did, in order to mitigate future harm.<sup>173</sup> This pressure also comes in spite of the fact that developing nations have an even more urgent need—thanks to this anthropogenic acceleration of global warming—to build the infrastructure necessary to withstand anticipated extreme weather events.<sup>174</sup> The Philippines is a perfect case study for these conflicting pressures and for the international compromises developed nations have made to assist developing countries in pursuing this sustainable development.

### 1. Regulatory Scheme

The Republic of the Philippines has implemented six major pieces of environmental legislation.<sup>175</sup> A 1978 Presidential Decree requires environmental impact statements for many major federal programs.<sup>176</sup> The Toxic Substances, Hazardous and Nuclear Waste Control Act of 1990 regulates the importation, sale, use, and disposal of hazardous substances.<sup>177</sup> Similar to the United States, the Philippine Clear Air Act of 1999 establishes air quality standards for the Philippines, and the 2004 Clean Water Act strives to minimize pollution and regulates the country's bodies of water.<sup>178</sup> The Ecological Solid Waste Management Act of 2000 aims to protect public health and the

172. *Id.*

173. See *EU Pressures Developing Nations to Cut Emissions*, EURACTIV (Jan. 29, 2009), <https://www.euractiv.com/section/development-policy/news/eu-pressures-developing-nations-to-cut-emissions/> [<https://perma.cc/3NHV-RFT7>] (archived Oct. 27, 2019) (describing a proposal delivered by the European Commission to replace the Kyoto Protocol on climate change, which urged rapidly developing countries like India and China to help reduce greenhouse gas emissions).

174. See Climate Reality Project, *How is Climate Change Affecting the Philippines?*, ECOWATCH (Jan. 22, 2016), <https://www.ecowatch.com/how-is-climate-change-affecting-the-philippines-1882156625.html> [<https://perma.cc/5MNU-UHS4>] (archived Oct. 27, 2019) (explaining how the absence of an infrastructure to respond to the effects of climate change prevents the Philippines from effectively addressing and responding to those effects).

175. *Major Environmental Laws*, REPUBLIC OF THE PHIL. ENVTL. COMPLIANCE ASSISTANCE CTR., [http://ecac.emb.gov.ph/?page\\_id=43](http://ecac.emb.gov.ph/?page_id=43) (last visited Feb. 28, 2019) [<https://perma.cc/SGT5-5DGB>] (archived Oct. 27, 2019) [hereinafter *Major Philippines Environmental Laws*].

176. See *id.*

177. An Act to Control Toxic Substances and Hazardous and Nuclear Wastes, Providing Penalties for Violations, Rep. Act. No. 6969, O.G. (Oct. 26, 1990) (Phil.).

178. An Act Providing for a Comprehensive Air Pollution Control Policy and for Other Purposes, Rep. Act. 8749, O.G. (June 23, 1999) (Phil.); An Act Providing for a Comprehensive Water Quality Management and For Other Purposes, Rep. Act 9525, O.G. (Mar. 2, 2004) (Phil.).

environment via the proper treatment and disposal of waste.<sup>179</sup> Finally, the Climate Change Act (CCA) of 2009 created a framework for addressing the nation's growing environmental concerns and established a Climate Change Commission (CCC), which is authorized to implement programs, policies, and regulations necessary to carry out the act.<sup>180</sup>

The CCC is the nation's primary climate policy-making body, and in 2011 it identified seven thematic areas for intervention and resilience building.<sup>181</sup> These are food security, water sufficiency, ecological and environmental stability, human security, climate-smart industries and services, sustainable energy, and knowledge and capacity development.<sup>182</sup> Another focus area is creating adaptation plans that are targeted towards particularly vulnerable communities, the Philippines' poor, and indigenous people.<sup>183</sup>

## 2. Challenges Posed by Climate Change

As an archipelagic nation comprised of over seven thousand individual islands, the Philippines is uniquely vulnerable to the increasingly drastic effects of climate change.<sup>184</sup> In its 2014 report, the Intergovernmental Panel on Climate Change identified its capital Manila as one of the most vulnerable cities in the world,<sup>185</sup> and in 2015, the Global Climate Risk Index listed the Philippines as the most affected nation in the world.<sup>186</sup> As sea levels rise and average global temperatures increase, the Philippines can expect to face more frequent flooding from tidal surges, to be battered by stronger storms and typhoons, and to experience even more severe droughts.<sup>187</sup> As a result, the Philippines should brace for a host of climate change—

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179. An Act Providing for an Ecological Solid Waste Management Program, Creating Necessary Institutional Mechanisms and Incentives, Declaring Certain Acts Prohibited and Providing Penalties, Appropriating Funds Therefor, and for Other Purposes, Rep. Act. 9003, O.G. (July 24, 2000) (Phil.).

180. See Climate Change and the Philippines Executive Brief No. 2018–01 7 (2018), [http://www.climate.gov.ph/images/knowledge/CC\\_Executive-Brief\\_V32.compressed.pdf](http://www.climate.gov.ph/images/knowledge/CC_Executive-Brief_V32.compressed.pdf) [<https://perma.cc/RW7E-AXBQ>] (archived Oct. 27, 2019) [hereinafter Philippines Executive Brief] (explaining how specific actions taken by the Climate Change Commission will address environmental issues resulting from climate change).

181. *Id.* at 8.

182. *Id.*

183. See *id.* at 10 (detailing the CCC's establishment of "comprehensive integrated climate adaptation and resilience program for all the Indigenous Peoples (IP) communities.").

184. Climate Reality Project, *supra* note 174.

185. John Vidal, 'We Expect Catastrophe'—Manila, the Megacity on the Climate Frontline, *GUARDIAN* (Mar. 31, 2014), <https://www.theguardian.com/environment/2014/mar/31/ipcc-climate-change-cities-manila> [<https://perma.cc/5263-BSWE>] (archived Oct. 27, 2019).

186. Climate Reality Project, *supra* note 174.

187. Vidal, *supra* note 185.



induced calamities.<sup>188</sup> Sixty percent of the nation's governmental units, which stretch across sixty-four coastal provinces, 822 coastal municipalities, and twenty-five major cities, are at risk of flooding thanks to sea level rise; they house 13.6 million Filipinos who will need to be relocated if the sea level continues to rise at its current rate.<sup>189</sup> By 2040, the Philippines is projected to face a high degree of water scarcity.<sup>190</sup> Ninety-eight percent of Southeast Asian coral reefs are expected to go extinct just a decade after that, leading to a maximum fish catch potential of just half of what it is today.<sup>191</sup> While the number of days with extreme rainfalls has increased, the nation as a whole has received less overall rainfall and experienced steadily rising temperatures.<sup>192</sup> Over one million hectares of the nation's grasslands are now highly vulnerable to fires.<sup>193</sup> For every degree Celsius that the average temperature increases, the nation will lose 10 percent of its agricultural yields, leading to increasing food scarcity, especially for vulnerable populations like the impoverished.<sup>194</sup> Hotter weather is also projected to decrease labor productivity by 4 percent by the end of the century.<sup>195</sup> Last, but certainly not least, is the increasing frequency at which scientists expect to see outbreaks of diseases like dengue, typhoid, cholera, and malaria, due to higher temperatures.<sup>196</sup>

While projections for the next several decades look especially dire, the people of Manila have been reeling from the effects of climate change for years already.<sup>197</sup> In 2009, for example, Tropical Storm Ondoy dropped a month's worth of rain in just a few hours, flooding 80 percent of the city, killing hundreds, and forcing hundreds of thousands to be evacuated.<sup>198</sup> In 2013, Super Typhoon Yolanda made landfall with winds that reached over 300 kilometers per hour (180 mph).<sup>199</sup> Over 6,300 Filipinos perished in the typhoon, making it the deadliest natural disaster in the history of the nation.<sup>200</sup>

The Philippines' unique susceptibility to the effects of climate change is due largely to two factors: its status as a still-developing

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188. Philippines Executive Brief, *supra* note 180, at 5.

189. *Id.*

190. *Id.*

191. *Id.* at 4.

192. *Id.*

193. *Id.*

194. *Id.* at 5.

195. *Id.*

196. *Id.*

197. Vidal, *supra* note 185 (describing a series of tropical storms and typhoons hitting the Philippines over the last decade).

198. *Id.*

199. Agence France-Presse, *Philippines Marks Five Years Since Its Deadliest Storm*, ABS CBN (Nov. 8 2018), <https://news.abs-cbn.com/news/11/08/18/philippines-marks-five-years-since-its-deadliest-storm> [<https://perma.cc/UL3Y-Z659>] (archived Oct. 27, 2019).

200. *Id.*

nation and its geography.<sup>201</sup> The unfortunate reality is that responding efficiently and successfully to natural disasters requires a well-developed infrastructure—one that the Philippines currently lacks.<sup>202</sup> A state needs to have evacuation plans, early-warning systems, and shelters in place in order for local authorities to be able to safely and quickly protect citizens.<sup>203</sup> These systems are vital in the event of typhoons or flooding, and especially when sudden disasters like earthquakes, mudslides, and tsunamis occur, all of which have plagued the Philippines.<sup>204</sup> In addition, the nation's people are spread out across its numerous islands, some of which lack basic infrastructure, which makes it even more difficult to mobilize hundreds, thousands, or even millions of people in times of crisis.<sup>205</sup>

The Philippines' geography also plays a significant role in increasing the country's vulnerability to climate change.<sup>206</sup> Regions near warmer bodies of water are naturally more prone to extreme weather events.<sup>207</sup> The surface of the ocean absorbs heat from sunlight during the day; when this heat is released into the atmosphere, it creates wind and rain clouds—the more heat, the stronger and more frequent the storms.<sup>208</sup> The nation's islands are located in the western Pacific Ocean, a naturally warm body of water that is getting steadily warmer as global temperatures rise.<sup>209</sup> In addition, the islands lack most forms of natural barriers—like nearby landmasses—that would help lessen the impact of extreme weather events.<sup>210</sup> While mangroves are native to the Philippines and help prevent erosion and protect cities from storm surge, nearly half of these trees have been lost to deforestation.<sup>211</sup> Coral reefs are also excellent natural barriers; they help absorb the shock of storms and tsunamis by breaking waves and reducing wave energy before it reaches the coast.<sup>212</sup> However, as stated above, the Philippines' reefs are not projected to survive beyond the next three decades.<sup>213</sup> The Philippines is one of the top four countries in the world most at risk for coral reef loss; theirs are being decimated by spikes in temperature, coastal development, sand mining, dynamite

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201. Climate Reality Project, *supra* note 174.

202. *Id.*

203. *Id.*

204. *Id.*

205. *Id.*

206. *Id.*

207. *Id.*

208. *Id.*

209. *Id.*

210. *Id.*

211. *Id.*

212. Marlowe Hood, *Flood Damage Would Double Without Coral Reefs*, PHYS.ORG (June 12, 2019), <https://phys.org/news/2018-06-coral-reefs.html> [<https://perma.cc/JT8G-52JR>] (archived Oct. 27, 2019).

213. Philippines Executive Brief, *supra* note 180, at 4.

fishing, and runoff from industry and agriculture.<sup>214</sup> Recent studies have indicated that, without coral reefs, coastal communities would face twice as much damage from flooding and triple the destruction from storm surges.<sup>215</sup>

### 3. Adaptation Programs

While the Philippines is still in the process of developing climate change adaptation mechanisms, the nation has been relatively proactive in comparison to other developing nations. Rather than investing in one large adaptation mechanism like MOSE, the Philippines has implemented dozens of smaller-scale, diverse projects to attack climate change from numerous different angles.<sup>216</sup> These projects are organized under five federally and foreign-funded programs: the People's Survival Fund, the Global Environmental Facility (GEF), the Millennium Development Goals Fund (MDGF), and the Adaptation to Climate Change and Conservation of Biodiversity Project as well as the National Framework Strategy on Climate Change (jointly GIZ Programs).<sup>217</sup>

The People's Survival Fund, elaborated on below, is a federal fund accessible to local government leaders to implement climate change-related programs.<sup>218</sup> All programs that are approved by the People's Survival Fund must be either mitigation-oriented or adaptation-oriented and grounded in climate science.<sup>219</sup> Successful projects that have emerged from this program so far include, first, the creation of a climate field school, which generates locally tailored climate information for the islands.<sup>220</sup> Second, is the Ridge to Reef Disaster

214. Hood, *supra* note 212.

215. *Id.*

216. See *Climate Change in the Philippines*, REPUBLIC OF THE PHIL., DEP'T SCI. & TECH., <http://bagong.pagasa.dost.gov.ph/information/climate-change-in-the-philippines> (last visited Feb. 9, 2019) [<https://perma.cc/D3V6-33Z6>] (archived Oct. 27, 2019) (listing various assisted climate change adaptation programs and projects being implemented in the Philippines) [hereinafter *Climate Change in the Philippines*].

217. See *infra* Part III.C.4 (explaining how the People's Survival Fund is federally-funded, while the other four are financed by foreign states and international organizations).

218. An Act Establishing the People's Survival Fund to Provide Long-Term Finance Streams to Enable the Government to Effectively Address the Problem of Climate Change, Amending for the Purpose Republic Act No. 9729, Otherwise Known as the "Climate Change Act of 2009", and for Other Purposes, Rep. Act. No. 10174, O.G., (July 25, 2011) (Phil.), <http://extwprlegs1.fao.org/docs/pdf/phi160804.pdf> (last visited Nov. 3, 2019) [<https://perma.cc/82RJ-V6JR>] (archived on Nov. 3, 2019) [hereinafter PSF Act].

219. Glenn S. Banaguas, *Accessing the People's Survival Fund*, MANILA TIMES (Mar. 9, 2017), <https://www.manilatimes.net/essence-accessing-peoples-survival-fund/316193/> [<https://perma.cc/UH3Y-8BPJ>] (archived Oct. 27, 2019).

220. PSF Bankrolls P192-Million Local Climate Change Adaptation Projects, CLIMATE CHANGE COMM'N (Mar. 8, 2018), <https://climate.gov.ph/news/46> [<https://perma.cc/BJK2-6CKB>] (archived Oct. 27, 2019).

Risk Reduction program, which has enabled local organizations to repropagate mangrove thickets along the coast and rehabilitate the natural ecosystems of several watersheds.<sup>221</sup> Third, is a program aimed at improving the islands' climate resilience via ecological-based farming practices.<sup>222</sup> These include diversifying seed stocks, planting stress-tolerant varieties of crops, adjusting planting and harvesting times based on weather forecast data, and composting.<sup>223</sup>

Through the GEF, the Philippines has increased its capacity to substitute diesel and gas for solar power, contributing to global mitigation efforts and furthering the nation's goal of sustainable industrial development.<sup>224</sup> A second GEF program focused on restoring watersheds to their maximum capacities to assuage water-scarcity concerns and help repair their natural ecosystems.<sup>225</sup> The MDGF has financed several adaptation and resiliency initiatives, including testing early warning systems in numerous communities, creating contingency plans for eighty-four municipalities, drafting a city shelter plan for Sorsogon City and retrofitting houses in numerous communities to be weather resilient.<sup>226</sup> Finally, the GIZ Programs have funded several projects focused on green economic development.<sup>227</sup> This has enabled nearly five hundred corporations to adopt green practices (i.e., energy-efficient facilities, better solid waste management, and locally sourced supplies).<sup>228</sup> Funds from the GIZ Programs have also financed climate-proofing training for local officials in coastal areas, the designation of more protected habitats, and more mangrove restoration.<sup>229</sup>

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221. *Id.*

222. *Id.*

223. See *Building Climate Resiliency in the Philippines*, GREENPEACE, <http://www.greenpeace.org/seasia/ph/What-we-do/Food-for-Life/building-climate-resiliency/> (last updated 2018) [<https://perma.cc/QRD8-2YT8>] (archived Oct. 27, 2019).

224. *Philippines: Country at a Glance*, GLOB. ENV'T FACILITY, <https://www.thegef.org/country/philippines> (last visited Jan. 20, 2020) [<https://perma.cc/ZGC3-PAHM>] (archived Oct. 27, 2019) (stating that the Philippines has received \$587.65 million in GEF grant funding).

225. *CTI Integrated Natural Resources and Environmental Management Sector*, GLOB. ENV'T FACILITY, <https://www.thegef.org/project/cti-integrated-natural-resources-and-environmental-management-sector> (last visited Nov. 3, 2019) [<https://perma.cc/P9WD-Y7AH>] (archived Nov. 3, 2019) (providing an overview of the project "[t]o restore productive capacity of critical watersheds, enhance biodiversity conservation in the production landscape and reduce poverty of resources-dependent communities in selected watersheds in the Philippines.").

226. *Philippines*, MDG ACHIEVEMENT FUND, <http://www.mdgfund.org/node/620> (last visited Feb. 9, 2019) [<https://perma.cc/2XQ5-2QS7>] (archived Oct. 27, 2019) [hereinafter MDG ACHIEVEMENT FUND].

227. *Green Economic Development*, DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH, <https://www.giz.de/en/worldwide/18237.html> (last visited Feb. 9, 2019) [<https://perma.cc/6A8Z-Z5HN>] (archived Oct. 27, 2019).

228. *Id.*

229. *Id.*

#### 4. Source of Funding

The Philippines has both the unique advantages and drawbacks of being a developing nation. While it lacks the vast tax base that developed nations like Italy and the United States have to draw from to fund adaptation mechanisms, its status as a developing country enables it to access a myriad of foreign and international financing sources.<sup>230</sup> This funding is funneled through the federal government to different federal, regional, and highly localized authorities, giving each of these officials the capacity to implement the adaptation strategies that work best for their own communities.<sup>231</sup> The most significant sources of funding for climate change initiatives in the Philippines come from the five programs listed above: the People's Survival Fund, the GEF Fund, the MDGF, and the joint GIZ Funds.<sup>232</sup>

In 2011, the CCA was amended to establish the People's Survival Fund, a "long-term finance stream to enable the government to effectively address climate change."<sup>233</sup> The CCA requires the government to earmark at least one billion pesos per year (\$19 million) for the fund.<sup>234</sup> Activities supported by the fund include adaptation programs, forecasting and early warning systems for natural disasters, and contingency planning for areas prone to these extreme events.<sup>235</sup> This funding is accessible to leaders at each level of government in the country.<sup>236</sup> Governmental authority is divided into Local Government Units (LGUs) in the Philippines.<sup>237</sup> There are three levels of LGUs: provinces and independent cities; followed by component cities (cities too small to be independent, and therefore considered part of their larger province) and municipalities; and, at the most local level, barangays (villages, districts, or neighborhoods).<sup>238</sup> LGU leaders at all levels can access the People's Survival Fund to augment their

230. See *Climate Change in the Philippines*, *supra* note 216 (listing various climate change adaptation programs funded by outside sources such as Spain, the World Bank, and Germany).

231. Kaye C. Revil et al., *Climate Change: Global Problem, Local Solution*, MANILA TIMES (Mar. 15, 2018), <https://www.manilatimes.net/climate-change-global-problem-local-solution/386328/> [<https://perma.cc/B9XT-LDHG>] (archived Oct. 27, 2019).

232. *Climate Change in the Philippines*, *supra* note 216.

233. PSF Act, *supra* note 218.

234. Revil et al., *supra* note 231.

235. PSF Act, *supra* note 218.

236. See Revil et al., *supra* note 231 (stating that while the government has earmarked one billion pesos for these efforts through the People Survival Fund, many local leaders were not aware that they could access the fund for local mitigation and adaptation efforts aimed towards climate change).

237. See *Barangay*, OXFORD LIVING DICTIONARIES, <https://en.oxforddictionaries.com/definition/barangay> (last visited Feb. 28, 2019) [<https://perma.cc/8UW8-E3TK>] (archived Oct. 27, 2019) (defining the word barangay as a "small territorial and administrative district forming the most local form of government" in the Philippines).

238. See PSF Act, *supra* note 218.

communities' climate change–related projects.<sup>239</sup> Given that this fund is perpetuated by money earmarked in the national budget, and one of the Philippines' largest sources of budgetary revenue is its progressive income tax, this fund comes (at least partially) out of Filipino citizens' pockets.<sup>240</sup> Fortunately for them, it is the only funding source that is domestically financed.<sup>241</sup>

The remaining major sources of funding for the adaptation mechanisms described above are financed entirely by developed foreign countries.<sup>242</sup> The Global Environmental Facility, for example, is a trust fund “available to developing countries and countries with economies in transition to meet objectives of international environmental conventions and agreement.”<sup>243</sup> It serves as the “financial mechanism” to implement five conventions, which include the United Nations Framework Convention on Climate Change (UNFCCC).<sup>244</sup> By ratifying the UNFCCC<sup>245</sup> and conforming with its eligibility criteria, the Philippines became eligible for this funding.<sup>246</sup> In 2018, thirty developed countries pledged \$4.1 billion to replenish the fund, which has provided over \$17 billion to eligible countries since its establishment in 1992.<sup>247</sup> The GEF provides funding in the form of a grant, not a loan, so recipient nations have no obligation to pay back donors.<sup>248</sup> This is financially advantageous for developing nations without the means to adapt to climate change on their own, but it also means that they necessarily sacrifice some autonomy over the

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239. Revil et al., *supra* note 231.

240. See An Act Amending Sections 5, 6, 24, 25, 27, 31, 32, 33, 34, 51, 52, 56, 57, 58, 74, 79, 84, 86, 90, 91, 97, 99, 100, 101, 106, 107, 108, 109, 110, 112, 114, 116, 127, 128, 129, 145, 148, 149, 151, 155, 171, 174, 175, 177, 178, 179, 180, 181, 182, 183, 186, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 232, 236, 237, 249, 254, 264, 269, 288; Creating New Sections 51-A, 148-A, 150-A, 150-B, 237-A, 264-A, 264-B, 265-A; and Repealing Sections 35, 62, 89; all under Republic Act No. 8424, otherwise known as the National Internal Revenue Code of 1997, as Amended, and for other purposes, Rep. Act 10963, O.G., (July 24, 2017) (Phil.) (setting income tax rates in the Philippines, tied to citizens' income levels).

241. See *Climate Change in the Philippines*, *supra* note 216.

242. See *id.*

243. *Funding*, GLOB. ENV'T FACILITY, <https://www.thegef.org/about/funding> (last updated 2018) [<https://perma.cc/6CJM-WZV8>] (archived Oct. 27, 2019) [hereinafter *GEF Funding*].

244. *Conventions*, GLOB. ENV'T FACILITY, <https://www.thegef.org/partners/conventions> (last updated 2018) [<https://perma.cc/22D2-AKF5>] (archived Oct. 27, 2019).

245. See *Parties & Observer States: Philippines*, UNITED NATIONS CLIMATE CHANGE, [http://unfccc.int/tools\\_xml/country\\_PH.html](http://unfccc.int/tools_xml/country_PH.html) (last visited Feb. 9, 2019) [<https://perma.cc/3SLT-SF7E>] (archived Oct. 27, 2019) (showing the official date of ratification as August 2, 2004).

246. See *GEF Funding*, *supra* note 243.

247. *Id.*

248. *Id.*

implementation of these mechanisms.<sup>249</sup> The General Secretariat oversees the implementation of GEF-funded projects and retains the authority to intervene if GEF policies are not followed.<sup>250</sup>

The Millennium Development Goals Fund was an international fund established through an agreement between the government of Spain and the United Nations, through which Spain has pledged more than \$1 billion to “accelerate progress towards key Millennium Development Goals”—targeting poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women in select countries, including the Philippines.<sup>251</sup> MDGF-1656 was the grant of \$8 million designated specifically for the Philippines.<sup>252</sup> Like the GEF grants described above, recipient countries had no obligation to pay the fund back, but were subject to a strict monitoring and evaluation system to maintain accountability.<sup>253</sup>

The German Corporation for International Cooperation (GIZ) is a development corporation that focuses on sustainable growth and social inclusion; through this agency, the German government has dedicated over 60 million EUR for the climate change adaptation projects described above.<sup>254</sup> The financing Germany provides the Philippines helps to fulfill Germany’s funding commitments under the UNFCCC, as well as increase the nation’s climate resiliency, protect its biodiversity and improve living conditions across the islands.<sup>255</sup> Similar to the GEF and MDGF, the Philippines must cooperate with the GIZ’s policies and terms but does not pay for its services.<sup>256</sup>

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249. See *Organization*, GLOB. ENV’T FACILITY, <https://www.thegef.org/about/organization#slide-7> (last updated 2018) [<https://perma.cc/L2WG-L32Y>] (archived Oct. 27, 2019).

250. *Id.*

251. *About Us*, MDG ACHIEVEMENT FUND, <http://www.mdgfund.org/aboutus> (last visited Feb. 9, 2019) [<https://perma.cc/8575-URUZ>] (archived Oct. 27, 2019).

252. See *Philippines: Strengthening the Philippines’ Institutional Capacity to Adapt to Climate Change*, MDG ACHIEVEMENT FUND, <http://www.mdgfund.org/program/strengtheningphilippines%E2%80%99institutionalcapacityadaptclimatechange> (last visited Nov. 3, 2019) [<https://perma.cc/2DJP-PFWM>] (achieved Nov. 3, 2019).

253. See *Monitoring and Evaluation*, MDG ACHIEVEMENT FUND, <http://www.mdgfund.org/content/monitoringandevaluation> (last visited Feb. 9, 2019) [<https://perma.cc/N4JW-7NB5>] (archived Oct. 27, 2019) (explaining the methods of monitoring and evaluation).

254. *Celebrating 10 Years IKI in the Philippines*, INT’L CLIMATE INITIATIVE (June 27, 2018), [https://www.international-climate-initiative.com/en/news/article/celebrating\\_10\\_years\\_iki\\_in\\_the\\_philippines/](https://www.international-climate-initiative.com/en/news/article/celebrating_10_years_iki_in_the_philippines/) [<https://perma.cc/3NG8-NC9Y>] (archived Nov. 9, 2019).

255. *Id.*

256. *Id.*

## IV. SOLUTION

When analyzed together, three common modes of adaptation become apparent across the regional case studies above: resistance, transformation, and retreat.<sup>257</sup> Each adaptation mechanism, from Miami to Venice to Manila, is designed to help populations—human, plant, and animal alike—either “resist the effects of climate change to maintain the status quo,” “transform physical, social, environmental or economic conditions . . . to minimize harm or maximize benefits associated with climate change impacts,” or move to less-affected locations.<sup>258</sup>

All resistance mechanisms can be further broken down into either “green” or “gray” infrastructural projects.<sup>259</sup> While governments have traditionally “defaulted” towards man-made, gray infrastructure, like building levees, elevating houses, and installing storm drains and sea walls, a new kind of infrastructure is on the rise.<sup>260</sup> Green infrastructure, also referred to as ecosystem-based adaptation,<sup>261</sup> utilizes an area’s natural ecosystem, incorporating local vegetation into its design or restoring habitats in order to prevent climate-related damage.<sup>262</sup> Common examples are repropagating coastal trees, like mangroves, or replanting flood plains to reduce flooding and erosion.<sup>263</sup> A recent study using Fiji as its model found that green infrastructure projects tend to be not only less expensive than gray infrastructure, but more effective at reducing climate-related damage as well.<sup>264</sup>

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257. J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 LEWIS & CLARK ENVTL. L. 363, 386 (2010).

258. *Id.*

259. See Andrew Wu, *Green Versus Gray Infrastructure: The Economics of Flood Adaptation in Fiji*, YALE ENV'T REV. (Sept. 1, 2016), <https://environment-review.yale.edu/green-versus-gray-infrastructure-economics-flood-adaptation-fiji-0> [<https://perma.cc/9435-RSKR>] (archived Oct. 27, 2019) (comparing and contrasting the benefits of green infrastructure versus gray infrastructure).

260. *Id.*

261. See Adam Daigneault et al., *Dredging Versus Hedging: Comparing Hard Infrastructure to Ecosystem-based Adaptation to Flooding*, 122 ECOLOGICAL ECON. 2, 25 (2015) (comparing ecosystem-based adaptation to hard infrastructure strategies).

262. See Wu, *supra* note 259.

263. See *id.* (describing “green” infrastructure methods to include replanting vegetation in headwaters and riparian zones to reduce flooding and erosion).

264. Daigneault et al., *supra* note 261.



Country	United States/South Florida <sup>265</sup>	Venice <sup>266</sup>	Philippines <sup>267</sup>
<b>Resist</b>	<p><b>Gray infrastructure</b></p> <ul style="list-style-type: none"> <li>• Elevating wastewater treatment facility</li> <li>• Raising roadways</li> <li>• Floodgates, seawalls, and tidal valves</li> <li>• Requiring new buildings to have elevated floors</li> <li>• \$400 million integrated pumping system</li> <li>• Construction of Port Miami Tunnel with floodgate</li> </ul> <p><b>Green infrastructure</b></p> <ul style="list-style-type: none"> <li>• Living Shorelines</li> </ul>	<p><b>Gray Infrastructure</b></p> <ul style="list-style-type: none"> <li>• Raising doorways</li> <li>• MOSE</li> </ul> <p><b>Green infrastructure</b></p> <ul style="list-style-type: none"> <li>• Restoring mudflats, salt marshes</li> <li>• Renourishing beaches, restore natural vegetation and species</li> </ul>	<p><b>Gray Infrastructure</b></p> <ul style="list-style-type: none"> <li>• Retrofitting houses to be climate resistant, including elevating them</li> <li>• City shelter plan</li> <li>• Sustainable economic development (energy-efficient facilities, waste management improvement, etc.)</li> </ul> <p><b>Green Infrastructure</b></p> <ul style="list-style-type: none"> <li>• Propagating mangrove thickets</li> <li>• Rehabilitating ecosystems</li> <li>• Restoring watersheds to maximum capacities (alleviating water scarcity)</li> <li>• Designation of more protected habitats</li> </ul>
<b>Transform</b>	<ul style="list-style-type: none"> <li>• No significant transformative projects yet</li> </ul>	<ul style="list-style-type: none"> <li>• No significant transformative projects yet</li> </ul>	<ul style="list-style-type: none"> <li>• Climate school for localized information so communities can better</li> </ul>

			change their habits/practices <ul style="list-style-type: none"> <li>• Ecological-based farming practices (changing crops, utilizing weather data, etc.)</li> <li>• Climate-proofing training for local officials</li> </ul>
<b>Retreat</b>	<ul style="list-style-type: none"> <li>• No significant retreat yet</li> </ul>	<ul style="list-style-type: none"> <li>• Abandoning first floors</li> </ul>	<ul style="list-style-type: none"> <li>• New warning systems, contingency plans</li> </ul>

When compared side-by-side (*see* Table 1), the strengths and weaknesses in each region's adaptation plans become apparent—and together, these case studies provide an excellent adaptation framework for cities across the world that are vulnerable to sea level rise.

#### A. Resistance

All cities that are vulnerable to sea level rise will have to implement at least gray infrastructural projects (or alter their existing infrastructure) in order to stave off flooding and other climate change-related damage. One strategy that was common among the three case studies was the elevation of doors and buildings in flood-prone areas.<sup>268</sup> Cities should consider following Miami's lead and regulating the height of all new structures.<sup>269</sup> By requiring buildings in floodplains to be elevated, governments can minimize flood damage, make communities more weather resilient, and mitigate the need to retreat from coastal areas.<sup>270</sup> Other gray mechanisms that may be helpful include Miami's array of drainage, seawall, and floodgate systems, as well as large-scale engineering projects like MOSE—these, however, are likely to

265. *See supra* Part III.A.3.

266. *See supra* Part III.B.3.

267. *See supra* Part III.C.3.

268. *See supra* Table 1.

269. *See supra* Part III.A.3.

270. *See* Ruggeri, *supra* note 80 (describing how developers in Miami recently built a new development higher than the current flood plain as an adaptation strategy).

vary greatly among cities, depending on their resources, layouts, and existing infrastructure already in place.<sup>271</sup>

Given that green infrastructure is both less costly and more effective at minimizing damage from sea level rise—making it ideal for developing nations with fewer resources—cities should place an even greater emphasis on these types of mechanisms in the coming decades.<sup>272</sup> The global community should look to Venice and the Philippines for guidance on green infrastructure, specifically repropagating coastal vegetation and rehabilitating coastal ecosystems to minimize erosion and flooding.<sup>273</sup> While South Florida has begun to venture into green infrastructure with projects like the Living Shorelines, the vast majority of funding and other resources have been directed towards hard infrastructure like drainage systems and seawalls.<sup>274</sup> The region's lack of green infrastructural projects is a gap in its adaptation strategy that South Florida should fill in order to combat sea level rise as economically and effectively as possible.<sup>275</sup>

### B. Transformation

Cities may be able to resist the effects of climate change to a certain extent through adaptation mechanisms, but in some scenarios, “the resist mode of adaptation is likely to be swamped by climate change.”<sup>276</sup> Cities simply will not be able to act fast enough to maintain the status quo and preserve their economic and property interests via resistance; instead, they will have to adapt by transforming.<sup>277</sup> Transformative adaptation methods can include anything from replacing one form of tourism with another (beach tourism with ecotourism, for example) to relaxing conservation goals from preserving species-specific health to conserving overall biodiversity, as the sea level rises and the *status quo* becomes more difficult to maintain.<sup>278</sup>

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271. See *supra* Part III.A.3.

272. See Wu, *supra* note 259 (identifying green infrastructure as a cost-effective method to address the effects of climate change).

273. See *supra* Parts III.B.3 & III.C.3.

274. See *supra* Part III.A.3.

275. See Rob McDonald, *Is Green Infrastructure Doomed to Underinvestment, Just Like Our Gray Infrastructure?*, COOL GREEN SCI. (July 7, 2016), <https://blog.nature.org/science/2016/07/07/green-infrastructure-doomed-underinvestment-grey-nature-based-solutions-investment/> [https://perma.cc/F6HM-Z6D8] (archived Oct. 27, 2019) (asserting that green infrastructure is underinvested in because of collective action failure and less immediately-realized benefits than gray infrastructure).

276. Ruhl, *supra* note 257, at 288.

277. See *id.* (asserting that the transformation mode of response occurs when a city acknowledges that maintaining the status quo is not feasible).

278. *Id.*

Neither South Florida nor Venice have implemented many transformative adaptation projects.<sup>279</sup> This is likely because cities that have the resources to do so prefer to dedicate them to preserving the interests they already have (like Miami's lucrative beach tourism industry or Venice's historical and cultural value), rather than acquiescing to climate change and adjusting their ways of life. The Philippines, on the other hand, has taken several strides towards transformative adaptation; these include switching to ecological-based farming practices and utilizing more climate data to adjust their agricultural practices and resource management accordingly.<sup>280</sup> Given its status as a developing nation and lack of existing infrastructure, the Philippines probably anticipates that the effects of climate change will move more swiftly than the nation can adapt by resistance; instead, transformation is the more feasible strategy. Developing nations around the world should look to the Philippines for guidance on how to similarly adjust their agricultural and economic practices if resistance is unfeasible.

### C. Retreat

Retreat is the least desirable of the three modes of adaptation—no city wants to relinquish any of its land or livelihood—but in some circumstances, it may be inevitable. In Venice, residents have been forced to abandon the ground floors of many of their buildings due to relentless flooding; this may constitute the earliest stage of retreat from the island city.<sup>281</sup> In the Philippines, while no significant retreat has taken place yet, officials are preparing for the possibility of a mass evacuation via the creation of contingency plans and installation of emergency warning systems.<sup>282</sup>

While retreat is certainly not ideal for any community, it is important for vulnerable municipalities—especially those in developing nations without the infrastructure to quickly notify and mobilize residents—to have emergency warning systems and evacuation plans in place. Cities around the world should look to the Philippines as a model for the implementation of strategies for a safe and expedient retreat, even if only a temporary one.

### D. Local Autonomy and Sources of Funding

When possible, nations should allow local governments to maintain as much autonomy over adaptation mechanisms in their

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279. See *supra* Table 1.

280. See *supra* Part III.C.3.

281. Livesay PBS Interview, *supra* note 138.

282. See *supra* Part III.C.3.

regions as possible.<sup>283</sup> There are numerous arguments to be made for why states and cities should retain control over this process. First, there are no “one-size-fits-all” adaptation strategies; while there may be similarities in the problems regions face (like flooding from sea level rise, for example), ultimately each city will need a nuanced solution that takes into account its specific resources, ecosystems, and more—and no actor has more expertise on a city’s unique circumstances than the city itself.<sup>284</sup> Second, local governments are able to address gaps or inefficiencies in federal policy through building codes and zoning ordinances.<sup>285</sup> Finally, local governments can function as test beds for alternative adaptation strategies and policies; if new policies are successfully implemented at a local level, they may be viable at the state or federal level as well.<sup>286</sup>

One major caveat to this is that many local governments will still need federal funding to implement adaptation mechanisms, even if the design and parameters of the mechanisms are left in their control. Similarly, developing nations have numerous foreign financing sources at their disposal for climate change adaptation projects.<sup>287</sup> But relying on federal or foreign funding may mean that cities necessarily sacrifice some oversight and stability, as the city of New Orleans did when the United States’ federal government shut down in early 2019 and funding for the coastal city’s projects temporarily froze.<sup>288</sup>

## V. CONCLUSION

While the effects of climate change are already visible, devastating, and far-reaching—especially in communities vulnerable to sea level rise—adaptation mechanisms may provide a path forward. When analyzed alongside each other, the strengths and weaknesses of South Florida, Venice, and the Philippines’ adaptation strategies are clear. They shape a model adaptation framework that can be imported to cities around the world, in developed and developing nations alike, in order to help them endure and even thrive in the face of climate change.

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283. See generally Goulder & Stavins, *supra* note 44 (discussing various arguments in support of state-level climate policy).

284. *Planning for Climate Change Adaptation*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/arc-x/planning-climate-change-adaptation> (last visited Feb. 28, 2019) [<https://perma.cc/63GF-LX56>] (archived Oct. 27, 2019) (acknowledging that there is no “one size fits all” approach for communities to address the evolving climate, as impact will vary around the country).

285. Goulder & Stavins, *supra* note 44, at 9.

286. *Id.*

287. See *supra* Part III.C.4.

288. Evans, *supra* note 93.

While cities will have to utilize gray infrastructural changes, like elevating buildings in flood-prone areas, they should also invest heavily in green infrastructure, specifically repropagating coastal vegetation and restoring these ecosystems in order to minimize damage from flooding and erosion. In communities where resisting the effects of climate change is no longer feasible—like developing nations without enough infrastructure in place to do so quickly—cities should focus on adjusting their agricultural and economic practices to adapt to their new environmental *status quos*. Finally, where resistance and transformation both fail, communities should have warning systems and evacuation plans in place; the time may come where retreat becomes their only option, and they will need to do so safely and efficiently.

Nations should allow local governments to maintain as much autonomy over the development and implementation of these adaptation strategies as possible, given that states and municipalities possess the most expertise on the unique challenges their communities face. However, developing nations should utilize the numerous foreign and international funding sources available to them, even when these require them to sacrifice some oversight of the implementation of adaptation programs.

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