
Rising Tides:

Assessing First and Third World Responses to the Threat of Sea Level Rise and Potential Adaptation Measures

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Executive Summary:

Over the last century, global temperatures have climbed at faster rates than ever before, causing sea levels to rise by an alarming 3.2 millimeters a year. As a result, these higher sea levels are threatening coastal cities across the world and adversely affecting people's livelihoods. This paper will examine Miami-Dade County in Florida and the country of Bangladesh, two very low-lying, coastal areas that are currently being tremendously affected by rising sea levels.

In Miami-Dade County, rising sea levels and saltwater intrusion have decreased economic prosperity by affecting real estate development, tourism, agricultural production, and in contaminating drinking water. In Bangladesh, sea level rise and increased salinity have also impacted economic prosperity by hurting agriculture, especially in regards to rice production. Additionally, increased salinity in drinking water has increased the risk for incidences of high blood pressure, stroke, and even cholera.

Sea level rise has also negatively affected insurance in both regions. In Miami-Dade County, flood insurance rates have increased at astronomical rates—forcing people to seek coverage from small, ill-equipped insurers, and even forcing some to leave altogether. In Bangladesh, flood and climate change related insurance is wholly inadequate, and as a result, most Bangladeshis affected by sea level rise are forced to migrate to nearby, already over-crowded cities or to India. However, some Indians are worried about increased job and resource competition with the migrants from Bangladesh, and conflict has increased.

Despite these challenges, Miami-Dade County and Bangladesh have made strides and implemented adaptation measures to address this issue. In Miami-Dade County, regional leaders have created various committees, conducted research, worked with nearby counties, and created better storm drainage systems. In Bangladesh, the government has written national plans of action on climate change, worked with NGOs in the country, set up two climate funds, and educated local communities on the potential impacts of SLR.

However, each region still faces challenges in adapting to SLR. In Miami-Dade County, support at the national level is lacking since the U.S. isn't even a party to the Kyoto Protocol, and state level support is virtually nonexistent, as leaders continually refute even the existence of climate change. In fact, the Governor has even banned members of the Florida Department of Environmental Impact from using certain climate change related words in their reports. Bangladesh, being a third world country, faces a severe lack of funding, capacity, and transparency that have all hindered the response.

Ultimately, Miami-Dade County and Bangladesh present two interesting case studies in that one is a region taking action at a sub-national level to address SLR, but lacking support at the state/national levels, while the other, is taking action at a national level, but facing obstacles to implementation at the sub-national level. Therefore, something must be done to ensure that both regions are able to adapt as effectively as possible to the threat of SLR. A system known as "linkages," developed by four professors/researchers under the Harvard Project on Climate Agreements, could help fill the gaps Miami-Dade County and Bangladesh face, and allow both regions to work together to better implement the adaptation plans they so desperately need.

The linkage system was developed with the intent of joining together nations, sub-nations, and other regions in an effort to better mitigate GHG emissions in the Earth's atmosphere. Linkages provide a variety of benefits in that they can encourage the flow of information between regions, lower the costs of mitigation globally, and still provide flexibility. Although the linkage system is used primarily for mitigation, this paper will introduce how it can be modified for adaptation purposes.

I. Introduction:

Sea level rise (SLR), caused by rising global temperatures, is a reality that threatens every nation in the world. While all nations will be affected in some way, coastal regions face the most direct threats from SLR and are struggling to cope with its effects. This paper will explore two regions vulnerable to SLR, Miami-Dade County, Florida, and Bangladesh. Miami-Dade County and Bangladesh, while different in many aspects, share the problem of being situated on low-lying coastlines that rest only a few feet above sea level. As a result, encroaching sea levels are causing declining economic prosperity, food/water insecurity, insurance issues, and increased migrations of business and people away from these regions. In focusing on a first and a third world region, this paper will investigate the different strategies each is employing to adapt to SLR—and the obstacles each is facing. In adopting and reworking a system known as “linkages,” which connects nations, sub-nations, and regions together to address mitigation, both Miami-Dade County and Bangladesh can work together to adapt effectively to SLR.

Section One: SLR and its Effects on Bangladesh and Miami-Dade County

I. Background on Projected SLR and its Causes:

From 1880 to 2012, the Earth's temperature (on land and sea) warmed by 1.5 degrees Fahrenheit (0.85 degrees Celsius).¹ As temperatures have risen, oceans have begun trapping more heat, and glaciers have started melting at unprecedented rates. Those rates are likely to increase, if, as climate scientists have predicted, the Earth's temperature rises between 2.5 to 10 degrees Fahrenheit by 2100.² More and more heat will be trapped in the atmosphere and the oceans, increasing the incidences of extreme weather events—leading to frequent flooding in some regions and droughts and wildfires in others. Meanwhile, oceans will continue to warm and swell. According to the National Center for Atmospheric Research, summer sea ice in the Arctic has decreased dramatically in the last fifty years, and could, by 2040, melt away completely.³

NASA has also found through satellite observations that September Arctic sea ice has declined at a rate of 13.3 percent each decade as compared to the average between 1981 and 2010.⁴ The National Resources Defense Council writes that the Greenland ice sheet, which contains ten percent of “total global ice mass” is rapidly melting—adding an

¹ “How Much Has the Global Temperature Risen in the Last 100 Years,” University Corporation for Atmospheric Research (UCAR), 2015, <https://www2.ucar.edu/news/how-much-has-global-temperature-risen-last-100-years>.

² “Global Climate Change: Effects,” NASA Global Climate Change: Vital Signs of the Planet, January 1, 2014, accessed January 8, 2015, <http://climate.nasa.gov/effects/>.

³ “Impacts of Global Warming on the Environment,” University Corporation for Atmospheric Research (UCAR), 2015, <https://www2.ucar.edu/news/backgrounders/impacts-global-warming-natural-systems>.

⁴ “Arctic Sea Ice Minimum,” NASA Global Climate Change: Vital Signs of the Planet, 2014, accessed January 8, 2015, <http://climate.nasa.gov/vital-signs/arctic-sea-ice/>.

estimated one-hundredth of an inch each year to the sea level.⁵ It predicts that if the entire mass melts, twenty-one feet could be added to the sea level. Additionally, as the oceans continue to warm, methane, stored on the sea level floor, will be released in higher quantities.⁶ As it is released, the methane will either be eaten by bacteria on the seafloor, (further acidifying the water and depriving it of oxygen) or the methane could rise to the surface and add to the greenhouse gases in the atmosphere.⁷

Through high-tech satellite missions, such as GRACE (The Gravity Recovery and Climate Experiment), SWOT (Surface Water and Ocean Topography), and Aquarius, data on sea level rise is more accurate than ever before.⁸ According to the IPCC's Fifth Assessment Report on climate change and sea level rise, the sea is expanding and warming at faster rates than even what was predicted in 2007 in the IPCC's Fourth Assessment Report. Between the year 0 A.D. and 1900, the sea level rose very minimally with normal fluctuations throughout. However, the tide changed in the 20th century, which brought a 1.7 mm increase each year—showing a significant shift.⁹ Today, scientists purport that since 1990, the sea level has been rising roughly 3.2 millimeters a

⁵ "The Consequences of Global Warming On Glaciers and Sea Levels," National Resources Defense Council, accessed January 7, 2015, <http://www.nrdc.org/globalwarming/fcons/fcons4.asp>.

⁶ Hannah Hickey, "Warmer Pacific Ocean Could Release Millions of Tons of Seafloor Methane," *University of Washington*, December 9, 2014, <http://www.washington.edu/news/2014/12/09/warmer-pacific-ocean-could-release-millions-of-tons-of-seafloor-methane/>.

⁷ Hannah Hickey, "Warmer Pacific Ocean Could Release Millions," 2014.

⁸ "Water: Satellite Missions Improve Water Estimates," *Apogeo Spatial*, accessed January 18, 2015, <http://apogeospatial.com/water/>.

⁹ John A. Church, Peter U. Clark, et al., "Working Group 1 Contribution to the IPCC Fifth Assessment Report on Climate Change: The Physical Science Basis," Intergovernmental Panel on Climate Change, 2013, accessed January 8, 2015, http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/drafts/fgd/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter13.pdf, 1139.

year.¹⁰ The IPCC has also predicted that if emissions continue to rise unabated, the seas will rise by between 45 and 82 centimeters, or 62 cm on average.

Of course, sea level rise is not uniform across the globe, but the IPCC report estimates that at least seventy percent of global coastlines will encounter the global average of a 62 centimeters rise in the next few decades. Coastal regions from New Orleans to Mumbai, Venice to Japan, and Miami to Bangladesh are experiencing the adverse effects of SLR at this very moment, and evidently, things are likely to get much worse. SLR is not an abstract idea or a distant threat—it is a global reality that must be addressed now to avoid major loss of life and regional stability. The next section will provide background on the regions of Miami-Dade County and Bangladesh, and discuss how SLR is impacting them.

II. Background on Miami-Dade County:

Miami-Dade County, located on the Southeastern tip of Florida, rests on one of the world's most threatened coastlines from SLR. Most of Miami-Dade County is elevated just six feet above sea level—at most. In fact, Miami-Dade County has more people living less than four feet above sea level than any other state in the U.S.—besides the state of Louisiana.¹¹ Additionally, most of the county is situated on limestone, a very porous, sponge-like rock that water easily permeates. This fact becomes even more ominous when one considers that Miami-Dade County has a population of roughly 2.6

¹⁰ John A. Church, “Working Group 1 Contribution to the IPCC Fifth Assessment Report,” 3.

¹¹ Forbes Tompkins, Christina Deconcini, “Sea Level Rise and it’s Impact on Miami-Dade County,” *World Resources Institute*, accessed January 8, 2015, http://www.wri.org/sites/default/files/sealevelrise_miami_florida_factsheet_final.pdf.

million—making it the seventh most populous county in the United States.¹² The World Resource Institute reports that the sea level along the coast in Southeast Florida already has risen by twelve inches, and that by the year 2060, it could increase by as much as two feet.¹³

Miami-Dade County also is home to many popular tourist destinations such as Miami Beach, the Everglades National Park, Big Cypress National Preserve, and Biscayne National Park. Historically, the region also has been a very popular place for real estate development, with many expensive restaurants, malls, and hotels crammed along the coast. According to Forbes, as of 2014, Miami Beach ranked thirty-fourth on its list of the five hundred most expensive zip codes in the United States.¹⁴ Overall GDP for the entire county is \$115 billion dollars, representing fifteen percent of Florida’s entire GDP.¹⁵ Therefore, Miami-Dade County is a highly developed region of the world that has a lot to lose from rising sea levels.

III. Background on the country of Bangladesh:

Bangladesh, the other region of exploration in this paper, also is extremely vulnerable to SLR. A small country located just east of India and on the Bay of Bengal,

¹² “State & County QuickFacts,” *United States Census Bureau*, accessed January 18, 2015, <http://quickfacts.census.gov/qfd/states/12/12086.html>.

¹³ Forbes Tompkins, “Sea Level Rise and it’s Impact,” *World Resources Institute*.

¹⁴ Erin Carlyle, “Full List: America’s 500 Most Expensive ZIP Codes in 2014,” *ForbesLife*, October 2014, <http://www.forbes.com/sites/erincarlyle/2014/10/22/full-list-americas-500-most-expensive-zip-codes-in-2014/>.

¹⁵ Dr. Robert D. Cruz, “Miami-Dade County: Current Economic Conditions,” (presentation, Greater Miami Chamber of Commerce Real Estate Committee Meeting, Miami-Dade County, FL, June 22, 2010).

Bangladesh has a population of roughly 156 million people, and a GDP of 150 billion.¹⁶ It also has the highest population density of any country in the world with 1,000 persons per one square kilometer.¹⁷ According to the National Community Development Network, or NCDO, the country has an average annual population growth rate of two percent—an astounding figure considering the previously mentioned population density figure.¹⁸ While Dhaka, the capital, is packed with people, seventy-five percent of the population actually lives in rural areas—depending on agriculture for survival.¹⁹ The most recent Human Development Report, which ranks countries based on education, income, and life expectancy, ranked Bangladesh near the bottom of its list at number 146 out of 187 countries.²⁰

The coastline of Bangladesh is about 580 kilometers long—with most of the coastline concentrated on the Ganges Delta (the largest river delta in the world). Bangladesh is less than ten meters above sea level, and ten percent of the population lives below a one-meter elevation.²¹ The climate is tropic, with frequent summer monsoons, cyclones, droughts, and floods. Despite a history of frequent floods, flooding from the sea has been increasing at an alarming rate. According to Dr. Pethik of Queen’s University in Belfast, high tides in Bangladesh are “rising ten times faster than the global average.” His

¹⁶ “Bangladesh: Country at a Glance,” *The World Bank*, 2013, <http://www.worldbank.org/en/country/bangladesh>.

¹⁷ Ibid

¹⁸ Anne-Katrien Denissen, “Climate Change and its Impacts on Bangladesh,” National Community Development Organization, accessed January 8, 2015, <http://www.ncdo.nl/artikel/climate-change-its-impacts-bangladesh>.

¹⁹ Anne-Katrien Denissen, “Climate change and its Impacts,” *National Community Development Organization*, last modified March 4, 2012, <http://www.ncdo.nl/artikel/climate-change-its-impacts-bangladesh>.

²⁰ “The Rise of the South: Human Progress in a Diverse World,” UNDP, (Human Development Report 2013), 2.

²¹ Denissen, “Climate Change and its Impacts,” 2012.

predictions for Bangladesh are that by the year 2100, sea levels there could rise up to four meters.²² The World Bank also reports that by 2070, 1.5 million people will be affected in some way by coastal flooding in the country.²³ Unlike Miami-Dade County, Bangladesh is much less developed, and most of the population is dependent for survival on agriculture, especially along the coast. While Bangladesh may not be as developed as Miami-Dade County, it too, will experience a significant decline in economic prosperity.

IV. SLR Effects on Economic Prosperity in Miami-Dade County:

Sea level rise decreases economic prosperity because coastal regions, especially in Miami-Dade County, are densely populated and harbor many important businesses that are integral to economic stability. In Miami-Dade County, real estate development is the cornerstone of economic growth. The World Resources Institute writes that Miami-Dade County has the “most exposed assets,” and that its beachfront property, not including infrastructure, is worth roughly \$14.7 billion.²⁴ In terms of overall property value, the Institute has calculated that there is \$38 billion dollars worth of property located just three feet above sea level, \$16 billion two feet above sea level, and close to \$7 billion only one foot above sea level.²⁵ With sea level rates projected to rise on the order of 3.2 millimeters a year, it is only a matter of time before these properties, worth billions of dollars, are forced to deal with devastating floods—and soon after, complete inundation.

²² Gardiner Harris, “Borrowed Time on Disappearing Land,” *New York Times*, last modified March 28, 2014, http://www.nytimes.com/2014/03/29/world/asia/facing-rising-seas-bangladesh-confronts-the-consequences-of-climate-change.html?_r=0.

²³ The World Bank, “Turn Down the Heat,” 2013, <http://www.worldbank.org/en/topic/climatechange/publication/turn-down-the-heat-climate-extremes-regional-impacts-resilience>, 129.

²⁴ Forbes Tompkins, Christina Deconcini, “Sea Level Rise and it’s Impact on Miami-Dade County,” *World Resources Institute*, accessed January 8, 2015, http://www.wri.org/sites/default/files/sealevelrise_miami_florida_factsheet_final.pdf, 3.

²⁵ *Ibid*, 1

Sea level rise also affects Miami Dade County's tourism, as many of the coast's beaches are eroding. As mentioned earlier, Miami-Dade County is home to many popular beaches, including Sunny Isles Beach, South Beach, and Miami Beach. In Florida, tourism is the state's most lucrative industry. In the Miami metropolitan area, tourism accounted for more than \$21 billion of the \$71.8 billion that was spent by tourists in 2012.²⁶ However, intruding seawater is starting to erode the very beaches Florida counts on to attract tourists. According to a study done by the Army Corps of Engineers, which is working with Miami-Dade County to try to adapt to SLR, the county will need "roughly 23 million cubic yards of beach re-nourishment (or the equivalent of more than 10,781 football fields covered in one foot of sand) over the next fifty years to sustain its beaches."²⁷ The report also found that the county has already used up all of its available, close-by domestic sand resources, and will soon need to find other means to fix this problem. The World Resource Institute writes that, according to the county's FY 2013-2014 Proposed Budget and Multi-Year Capital Plan, between 2013-2017, more than \$32 million dollars will need to be spent in order to re-nourish the beaches.²⁸

SLR also forces the county to find different and more expensive water sources to provide its citizens—costing the county millions. Once too much salt begins seeping into aquifers, which is very common due to Miami-Dade County's porous limestone, the water becomes undrinkable. In Hallandale Beach, located just north of Miami, six

²⁶ Ibid, 3

²⁷ Ibid, 2

²⁸ Ibid.

of its eight wells have been closed down because of saltwater intrusion.²⁹ In order to build six replacement wells, the cost would be close to \$10 million. In the interim, the town has been forced to buy half of its water supply from nearby Broward County.³⁰ The World Resources Institute reports that close to seventy percent of the drainage capacity of 28 coastal flood/salinity control structures may no longer be usable even with a three to nine inch rise in sea level.³¹ Advanced pumping stations may be needed—costing close to \$70 million each. It is also estimated that just three pumping stations could cost Miami-Dade County as much as \$200 million to construct.³² Saltwater intrusion will also affect some of Miami’s major crops—citrus, tomatoes, limes, and sugarcane, wreaking more havoc on the economy, decreasing exports, and affecting people’s livelihoods.³³ According to research conducted by the University of Florida, in Miami-Dade County, the agricultural sector in the county has created 222,402 jobs, creating about \$13.31 billion in revenue for the county.³⁴ With a 700-millimeter increase in SLR, the entire state of Florida could lose up to 37,500 acres of farmland.³⁵

²⁹ Jeff Goodell, “Why the City of Miami is Doomed to Drown,” *Rolling Stone*, June 20, 2013, <http://www.rollingstone.com/politics/news/why-the-city-of-miami-is-doomed-to-drown-20130620?page=5>.

³⁰ Jeff Goodell, “Why the City of Miami is Doomed to Drown,” *Rolling Stone*.

³¹ Forbes Tompkins, “Sea Level Rise and it’s Impact on Miami-Dade County,” *World Resources Institute*, accessed January 8, 2015, http://www.wri.org/sites/default/files/sealevelrise_miami_florida_factsheet_final.pdf, 3.

³² *Ibid.*, 3.

³³ Laura Parker, “Treading Water,” *National Geographic*, February 2015.

³⁴ Mitchell A. Chester, “Economic Impacts,” *Raisingfields.org*, February 21, 2015, <http://www.raisingfields.org/#!/facts--numbers/c966>.

³⁵ Tricia Woolfenden, “Miami Among Most at Risk for Sea Level Rise, Federal Climate Change Report Says,” *WLRN*, February 22, 2013, <http://wlrn.org/post/miami-among-most-risk-sea-level-rise-federal-climate-change-report-says>.

One approach to remedy this problem has been to drill new wells, however, there is only so far they can go until they reach the Everglades.³⁶ Some engineers have proposed capturing storm water and storing it, but the most popular method is using desalination plants. While these are all smart ideas, the costs are extremely high, especially for desalination. Running a desalination plant can cost five to ten times more than just extracting water from a natural aquifer.³⁷ Furthermore, 1/3 of the cost of running a desalination plant goes towards energy consumption.³⁸ It is clear that the cost of dealing with sea level rise is quite high in Miami-Dade County, and will only continue to increase.

V. SLR Effects on Economic Prosperity in Bangladesh:

In Bangladesh, SLR is also expected to greatly diminish economic prosperity, not by affecting beachfront development and tourism, but by affecting agriculture—one of the biggest job providers in the country. Bangladesh is considered a third-world country, with a very underdeveloped economy. As a result, most of the population relies on agriculture to survive. According to the Ministry of Finance, agriculture contributes roughly twenty percent to Bangladesh's GDP.³⁹ Crop cultivation represents over half of that twenty percent figure, with livestock, fisheries, and forestry making up the rest.

³⁶ Jeff Goodell, "Why the City of Miami," *Rolling Stone*, 2013.

³⁷ Nicholas Gerbis, "We Can't Convert Salt Water into Drinking Water," *HowStuffWorks*, last modified February 16, 2010, <http://adventure.howstuffworks.com/survival/wilderness/convert-salt-water.htm>, 3.

³⁸ Forbes Tompkins, *Sea Level Rise and its Impacts*, 3.

³⁹ Timothy S. Thomas, Khandaker Mainuddin, et al, "Agriculture and Adaptation in Bangladesh: Current and Projected Impacts of Climate Change," International Food Policy Research Institute, last modified July 2013, <http://www.ifpri.org/sites/default/files/publications/ifpridp01281.pdf>.

Additionally, agriculture provides employment to some of Bangladesh's poorest—providing work to about fifty-two percent of the labor force.⁴⁰

In the World Bank's 2013 "Turn Down the Heat Report," researchers projected a dire future for the stability of agricultural production and the country's GDP. The report explains that rice production will be greatly affected because the main area where rice is cultivated, the Ganges-Brahmaputra-Meghna Delta (GBM), sits only five meters above sea level.⁴¹ The GBM delta also provides the country with thirty-four percent of its total rice production.⁴² Researchers estimate that as flooding gets worse, rice will be severely threatened, not only taking away people's livelihoods, but severely reducing production of one of the nation's most important staple crops. Additionally, the report projects that SLR could cause an 80 million-ton reduction in rice production between 2005 and 2050, which translates to 3.9 percent annually.⁴³

Just as in Miami-Dade County, economic prosperity will also decline in Bangladesh due saltwater intrusion—destroying staple crops and making drinking water undrinkable. According to Bangladesh's National Adaptation Plan of Action (NAPA), "out of 2.85 million hectares of coastal offshore areas, 1.2 million hectares of arable land will be affected by varying degrees of soil salinity."⁴⁴ According to a report by the department of Crop Botany at Bangladesh Agricultural University, researchers predict

⁴⁰ Timothy S. Thomas, "Agriculture and Adaptation in Bangladesh," 2013.

⁴¹ The World Bank, "Turn Down the Heat," 2013, <http://www.worldbank.org/en/topic/climatechange/publication/turn-down-the-heat-climate-extremes-regional-impacts-resilience>, 167.

⁴² Ibid.

⁴³ The World Bank, "Turn Down the Heat," 172.

⁴⁴ Ministry of Environment and Forest Government of the People's Republic of Bangladesh, "National Adaptation Program of Action," UNDP, <http://unfccc.int/resource/docs/napa/ban01.pdf> (accessed January 11, 2015), 4.

that the coastal regions of Khulna, Barisal, and Chittagong, which lie only one meter above sea level, will be “inundated and unsuitable” for crop production within the next fifty years due to salt water intrusion.⁴⁵ When saltwater gets into the ground, the chemistry of the soil can be entirely altered, and, as written in the NAPA, “prolonged inundation inhibits the fixation of free nitrogen and halts mineralization, thus impairing soil fertility within a few years.”⁴⁶ Bangladesh’s NAPA also notes that saline water, aside from affecting crops, will also affect power stations. In the coastal city of Khulna, for example, a lack of fresh water, used for cooling, will force these power stations to send barges further upstream for fresh water.⁴⁷

In addition to being detrimental to agriculture, saline water may cause greater incidences of disease in Bangladesh. Saltwater intrusion into water supplies can have dangerous effects on the human body. In Miami-Dade County, where saltwater is also seeping into aquifers, the county is more equipped to deal with the problem by setting up desalination plants and buying water from nearby counties. Bangladesh, however, is not as fortunate. According to the World Bank, twenty million Bangladeshis are affected by saltwater intrusion into their drinking supply. In Bangladesh, according to the Grantham Institute on Climate Change and the Environment, people along the coast are receiving fifty to one hundred percent more of the recommended daily salt

⁴⁵ Halim Khan, A. Awal, “Global Warming and Sea Level Rising: Impact on Bangladesh Agriculture and Food Security,” National Food Policy Capacity Strengthening Programme, April 2009, http://www.nfpcsp.org/agridrupal/sites/default/files/Final_Technical_Report_CF_10_Approved.pdf, 29.

⁴⁶ M.S. Hossain, M.J. Uddin, A.N.M. Fakhruddin, “Impacts of Shrimp Farming on the Environment of Bangladesh and Approach for Management, *Reviews in Environmental Science and Bio/Technology* 12, no. 3 (2013): 320.

⁴⁷ Ministry of Environment and Forest, “National Adaptation Program of Action (NAPA),” 7-8.

intake.⁴⁸ Higher levels salt can increase ones chances for high blood pressure, a stroke, heart attack, and/or cardio-vascular disease.⁴⁹ Saltwater intrusion also can cause more frequent outbreaks of cholera because *vibrio cholerae*, the bacterium that causes the disease, thrives better in saltwater.⁵⁰ Unlike in Miami-Dade County, a region financially equipped to run desalination plants and buy water from nearby counties, Bangladesh will have a much harder time finding the resources necessary to address this issue. Therefore, it is likely the economy will continue to suffer.

VI. Effects of SLR on Miami-Dade County’s Everglades and Bangladesh’s Sundarbans:

Both Bangladesh and Miami-Dade County have natural treasures that are vulnerable to the effects of SLR. In the county, there are the Everglades, and in Bangladesh, the Sundarbans; both are large and ecologically important wetlands that are changing drastically due to SLR. The Everglades is a two million acre wetland that is home to many plant species like mangroves, saw grass, cypress, pine trees, and bladderwort; it is also home to many animals, such as alligators, storks, herons, manatees, panthers, snakes, and much more.⁵¹ This expansive wetland spans across many counties in Florida, but one-third of the Everglades are located within Miami-Dade County.⁵²

⁴⁸ “The Effects of Sea Level Rise on Human Health,” *Imperial London College*, accessed January 10, 2015, <http://www.imperial.ac.uk/grantham/our-work/impacts-and-adaptation/ipcc-working-group-ii/sea-level-rise/>.

⁴⁹ “The Effects of Sea Level,” *Imperial London College*, accessed January, 2015.

⁵⁰ The World Bank, “Turn Down the Heat,” 147.

⁵¹ “Everglades,” *National Wildlife Federation*, accessed January 15, 2015, <http://www.nwf.org/wildlife/wild-places/everglades.aspx>.

⁵² “About Miami-Dade County,” *Miamidade.gov*, accessed January 31, 2015, http://www.miamidade.gov/info/about_miami-dade.asp.

In Bangladesh, another treasured wetland is threatened by sea level rise and salinity. The Sundarbans, a 10,000 square kilometer wetland forest and UNESCO World Heritage Site, is home to roughly 400 fish species, 270 species of birds, and more than 300 plant species.⁵³ As in the Everglades, many migratory birds and bengal Tigers also depend on the Sundarbans for survival.⁵⁴ The Sundarbans also is the largest mangrove forest in the world. According to a paper in the *International Journal of Ecological Economics & Statistics*, “the Sundarbans forest constitutes about 51% of the forest area of Bangladesh and contributes about 50% of the revenue earned by the forest sector. It also is estimated that over six million people benefit directly or indirectly from the Sundarbans mangrove resources.”⁵⁵ Evidently, both the Sundarbans and the Everglades serve many important functions, not just for the animals living in them, but also for the people around them.

Unfortunately, due to SLR, many of the integral plant and animal species in the Everglades and the Sundarbans are becoming increasingly threatened. For example, in the Everglades, satellite imagery, utilized by the University of Miami, discovered that the saw grass habit is greatly receding, whereas some of the saline tolerant mangrove species are growing in number.⁵⁶ The University’s research also found that much of the

⁵³ Jeremy Hance, “A Key Mangrove Forest Faces Major Threat from a Coal Plant,” *Yale Environment 360*, October 29, 2013, http://e360.yale.edu/feature/a_key_mangrove_forest_faces_major_threat_from_a_coal_plant/2704/.

⁵⁴ Ministry of Environment and Forest, “National Adaptation Program of Action (NAPA),” 5.

⁵⁵ M. Shafi N. Islam, Albrecht Gnauck, “Threats to the Sundarbans Mangrove Wetland Ecosystems from Transboundary Water Allocation in the Ganges Basin: A Preliminary Problem Analysis,”

International Journal of Ecological Economics & Statistics 13, no. 9 (2009): 65.

⁵⁶ Maria Guma-Diaz, Annette Gallagher, “Rising Sea Levels Threaten Everglades Freshwater Plants,” *University of Miami*, last modified October 9, 2013,

vegetation near the coast (approx. four kilometers from the shore) has been moving inland for the last seventy years.⁵⁷ As saline water continues moving further inland, soil mineralization will increase, changing the makeup of the land.⁵⁸ The researchers write that it is “highly likely” saltwater will intrude into southern portions of the Everglades that have not experienced saline water before.⁵⁹

In the Sundarbans, the most saline-tolerant mangrove species also are growing in number while the freshwater species, also known as Sundari trees or *Heritiera fomes*, are “top-dying,” which means they are slowly expiring from the top down.⁶⁰ Aside from the loss of these important trees, mangrove forests also act as storm buffers and provide Bangladeshi’s with honey, crabs, fish, and wood.⁶¹ Worldwide, mangroves serve very important functions in helping to sequester carbon, which helps mitigate the effects of climate change. In fact, mangrove forests capture 50% of all the green carbon in the world, and can store five times more carbon than other tropical forests in the world.⁶² Additionally, according to Conservation National, roughly 80% of global fish catches are

http://www.miami.edu/index.php/features/rising_sea_levels_threaten_everglades_freshwater_plants/.

⁵⁷ Marie Guma-Diaz, “Rising Sea Levels Threaten Everglades Freshwater Plants,” 2013.

⁵⁸ Courtney T. Hackney, Asher Williams, “Impact of Sea Level Rise and Salt Intrusion on Everglades Peat: Review and Recommendations,” *University of North Florida*, June 22, 2012, http://www.evergladesplan.org/pm/ssr_2014/Docs/everglades_peat_impacts_slr_salt_intrusion.pdf.

⁵⁹ Courtney T. Hackney, Asher Williams, “Impact of Sea Level Rise and Salt Intrusion on Everglades Peat: Review and Recommendations,” 2012.

⁶⁰ Awal Mohd Abdul, “Analysis of Environmental Pollution in Sundarbans,” *American Journal of Biomedical and Life Sciences*, 2, no. 5 (2014).

⁶¹ “Sea-Level Rise in Bangladesh and the Netherlands,” Germanwatch.org, 2004, <http://germanwatch.org/download/klak/fb-ms-e.pdf>.

⁶² “Mangroves more Carbon Rich and Important for Climate Change,” *The Center for People and Forests*, 2011, <http://www.recoftc.org/project/grassroots-capacity-building-redd/news-and-features/mangroves-more-carbon-rich-and-important-climate-change>.

dependent in some way on mangroves.⁶³ Clearly, the disruption of these natural wetlands will cause drastic ecological changes and dramatically increase both regions' risk for disaster.

VII. SLR Effects on Insurance in Miami-Dade County:

Another major problem created by SLR is its impact on insurance coverage against natural disasters such as floods. As sea levels have risen, insurance companies have raised their coverage rates or have even stopped offering property insurance altogether. Swiss Re, a reinsurance company that Miami-Dade County officials consulted on SLR's effect on the economy, estimates that losses for Southeast Florida will be around \$33 billion or close to ten percent of GDP by the year 2030.⁶⁴ Insurance companies are very aware of the effects of SLR, and have begun insulating themselves by raising rates and denying coverage. However, those practices will have a catastrophic domino effect because "as insurance rates climb, fewer are able to afford homes. Housing prices fall, which slows development, which decreases the tax base, which makes cities and towns even less able to afford the infrastructure upgrades necessary to adapt to rising seas."⁶⁵ It's a vicious cycle that ends up affecting all sectors of the economy, not just homeowners.

⁶³ Emily Pidgeon, "Sequestration of Carbon Along Our Coasts: Important Sinks and Sources," Conservation International, <http://www.cbd.int/cooperation/pavilion/cancun-presentations/2010-12-1-pidgeon-en.pdf>.

⁶⁴ Miami-Dade County Sea Level Rise Task Force, "Miami-Dade Sea Level Rise Task Force Report and Recommendations," July 1, 2014, <http://www.miamidade.gov/planning/library/reports/sea-level-rise-report-recommendations.pdf>, (accessed January 20, 2015).

⁶⁵ Jeff Goodell, "Why the City of Miami," 2013.

The situation becomes even more dire when coverage is denied entirely. For example, after Hurricane Andrew hit the county in 1992, many of the largest insurers most capable of helping property owners refused to continue coverage.⁶⁶ As a result, only small, regional insurers that were financially ill equipped to deal with the problem were left. In 2002, in order to fix this problem, the Florida legislature set up a statewide insurance company called Citizens Property Insurance to help cover those who weren't being covered in the private sector, and to ensure that development would continue along the coast. Today, it is the largest insurer in Florida. However, in a 2013 press release, Jose Diaz, the Miami-Dade County Commissioner, spoke out against the state insurer, citing that insurance rates were too high for the County's citizens, and that a task force should be created to explore the issues.⁶⁷

Another non-private insurer is FEMA's National Flood Insurance Program (NFIP). However, many also have expressed frustration with this organization over exorbitant insurance premiums reaching up to \$24,000, which is an astounding increase of \$21,000.⁶⁸ Furthermore, the program is running a huge deficit of \$24 billion, showing that it is not as equipped to deal with sea level threats as it needs to be.⁶⁹ Evidently,

⁶⁶ Lynne McChristian, "Hurricane Andrew and Insurance: The Enduring Impact of An Historic Storm," Insurance Information Institute, 2012, http://www.iii.org/sites/default/files/paper_HurricaneAndrew_final.pdf.

⁶⁷ "Commissioner Jose "Pepe" Diaz to present Homeowners Insurance Task Force," [MiamiDade.gov](http://www.miamidade.gov), March 28, 2013, <http://www.miamidade.gov/district12/releases/2013-03-28-homeowners-insurance-taskforce.asp>.

⁶⁸ Marianela Toledo, "A \$24,000 Flood Insurance Policy? Welcome to Florida's New Normal," *Sunshine State News*, January 14, 2014, <http://www.sunshinestateneews.com/story/24000-flood-insurance-policy-welcome-florida's-new-normal>.

⁶⁹ Richard Davies, "US House Passes Homeowner Flood Insurance Affordability Act," *FloodList*, March 5, 2014, <http://floodlist.com/insurance/us/house-passes-homeowner-flood-insurance-affordability-act>.

SLR is proving to be a major issue with regards to insurance, and many current homeowners and businesses will face obstacles in trying to get insured. As a result, many homeowners may be forced to leave the county to avoid paying these high insurance rates, and certainly those considering moving to Miami-Dade County will look at these rates and most likely rethink moving there.

VIII. Lack of Insurance in Bangladesh and Migration to India due to SLR:

In Bangladesh, flood insurance is rudimentary at best, and as a result, many Bangladeshis are being forced to flee the country altogether. International institutions like the United Nations, and the World Bank have begun developing plans to help some of the poorest people in least developing countries (LDC's) obtain insurance, but they are still largely inadequate to address the needs of millions of people. In Bangladesh, there are three commercial insurance companies, one state owned company and nine microfinance institutions that provide microfinance to some of the poorest members of society.⁷⁰ However, most of these insurance companies, and especially the traditional microfinance institutions are not equipped to provide insurance for climate change related impacts, which are growing in severity. Additionally, despite the seemingly popular use of microfinance in Bangladesh, 94% of Bangladeshis are still uninsured.⁷¹ Additionally, microfinance, being that it is a form of self-insurance, deviates from the main goal of insurance, which is to pool risks and spread them across different parties so that negative

⁷⁰ Shahadat Hossain, "Problems and Prospects of Weather Index Based Crop Insurance for Rural Farmers in Bangladesh," *International Institute for Science, Technology, and Education*, 2013, <http://iiste.org/Journals/index.php/DCS/article/viewFile/8696/8932>.

⁷¹ Ainun Nishat, Nandan Mukherjee, Erin Roberts, Anna Hasemann, "A Range of Approaches to Address Loss and Damage from Climate Impacts in Bangladesh," *UK Department for International Development*, 2013, <http://www.lossanddamage.net/download/7069.pdf>.

impacts are lessened.⁷² Therefore, with increased climate events likely to occur, microfinance, at least in its current form, will not be very helpful in protecting coastal Bangladeshis.

One form of insurance that is becoming popular in some developed countries to make up for this gap is something called weather index based insurance. Weather index based insurance is a relatively new concept that is “a contingent claim contract for which payment is based on specific objective weather parameter that is closely correlated with farm level yields or revenue outcomes.”⁷³ In the 1980s, state insurer, Sadharan Bima Corporation, tried instituting crop insurance in Bangladesh, but failed due to cost ineffectiveness and corruption.⁷⁴ Currently, there are still no index based insurance products available for desperate farmers impacted by SLR and increased salinity, and, implementing this type of insurance has many flaws that have yet to be worked out. For example, weather index based insurance “is not designed to cover the losses of individual farmers, but of crops across a specified region,”⁷⁵ which is an unappealing feature for many potential consumers. Overall, insurance that specifically deals with extreme weather events and climate change impacts is in a very infant stage in the developing world. Additionally, as in Miami-Dade County’s situation, it is highly

⁷² Ibid.

⁷³ Dr. Md. Mushfiqur Rahman, Bikash Chandra Ghosh, Dr. Mir Khaled Iqbal Chowdhury, “Problems and Prospects of Weather Index Based Crop Insurance in Developing Countries: A Case for Rural Farmers in Bangladesh,” *Journal of Humanities and Social Science* 19, no. 9 (2014): 47.

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⁷⁵ Syful Islam, “Bangladesh to Trial Weather Index-Based Crop Insurance,” Thomson Reuters Foundation, 2012, <http://www.trust.org/item/?map=bangladesh-to-trial-weather-index-based-crop-insurance/>.

likely that most insurance companies won't want to provide insurance for climate related impacts in Bangladesh. Therefore, many are forced to flee their homes altogether.

Due to a lack of comprehensive insurance in Bangladesh, millions along the coast have been forced to flee—creating conflict and tension. Many Bangladeshis are moving to slums in the capital, Dhaka—which is home to over fifteen million people. One figure estimates that close to 1.5 million of the five million inhabitants of Dhaka's slums have come from the Bay of Bengal, which is on the coast.⁷⁶ This is a dangerous trend because more people in Dhaka's slums will overburden an already extremely poor, overcrowded, and underdeveloped city.

Of course, not all of these migrants are leaving the coast because of SLR, but it is becoming a driving factor. UNESCO's report on the link between water stress and migration explains that “climate change-induced migration causes a vicious cycle, whereby climate change leads to water stress, which leads to conflict, which leads to more migration, which leads to increasing pressures on water resources, thus increasing water stress and conflict, which in turn further fuels migration.”⁷⁷ It is estimated that by 2050, between twenty to thirty million Bangladeshis could be migrating due to climate change—creating “the worst migration in human history.”⁷⁸ This vicious cycle is playing out right now within Bangladesh, and also in India—another migration destination for many Bangladeshis escaping SLR.

⁷⁶ Gardiner Harris, “Borrowed Time on Disappearing Land,” *The New York Times*, Marc 28, 2014, http://www.nytimes.com/2014/03/29/world/asia/facing-rising-seas-bangladesh-confronts-the-consequences-of-climate-change.html?_r=0.

⁷⁷ Michael R. van der Valk, Penelope Keenan, “Climate Change, Water Stress, Conflict, and Migration” (presentation, Conference at The Hague, the Netherlands, September 2011), 13.

⁷⁸ *Ibid.*, 95.

Bangladesh and India share a 2,545-mile long land border on three sides, and because of their close proximity, millions of Bangladeshis are migrating to nearby India.⁷⁹ The Indian government claims that five million Bangladeshis are living in the country illegally, and this creates contention between the two countries.⁸⁰ In December of 2008, the National Defense University in Washington D.C. conducted an exercise that “explored the impact of a flood that sent hundreds of thousands of refugees into neighboring India. The exercise predicted a new wave of migration would touch off religious conflicts, encourage the spread of contagious diseases, and cause vast damage to infrastructure.⁸¹ In fact, after many Bangladeshis migrated to India in the 1980s, escaping from environmental threats, violence broke out.⁸² As a result, the ruling parties in India, both past and present, have tried to make it harder for Bangladeshis to come into the country—inciting further hostilities against Bangladeshis and setting the stage for violence.

The ruling party of India, the Bharatiya Janata Party (BJP), is known for its more right-wing nationalistic views, and some party leaders have publicly expressed their dislike of Bangladeshis and have even been accused of inciting conflict. Sadly, in 2012, in Assam, India, around forty Muslims were murdered because they were

⁷⁹ Lisa Friedman, “A Global National Security Issue Lurks at Bangladesh’s Border,” *The New York Times*, March 23, 2009, <http://www.nytimes.com/cwire/2009/03/23/23climatewire-a-global-national-security-issue-lurks-at-ba-10247.html?pagewanted=all>.

⁸⁰ Lisa Friedman, “A Global National Security Issue,” 2009.

⁸¹ Michale Werz, Laura Conley, “Climate change, Migration, and Conflict,” *The Center for American Progress*, January 2012, https://cdn.americanprogress.org/wp-content/uploads/issues/2012/01/pdf/climate_migration.pdf.

⁸² Rafael Reuveny, “Climate Change-Induced Migration and Violent Conflict,” *Political Geography*, 26, (2007): 660.

suspected of being immigrants from Bangladesh.⁸³ Many believe that Narendra Modi, President of India and leader of the BJP, helped incite the violence by delivering a fiery anti-immigration speech a few days earlier near the town.⁸⁴ He also has been quoted as saying that he wants to “send these Bangladeshis beyond the border with their bags and baggages.”⁸⁵ Therefore, tensions are running high in India, and government rhetoric isn’t helping the situation.

One way the Indian government has tried to discourage immigration is by creating a gigantic border security wall. This wall is a 2,500 mile-long wall that runs along the border between India and Bangladesh.⁸⁶ However, according to an extensive report by the organization Human Rights Watch, numerous human rights violations against immigrants from Bangladesh have occurred along this wall. A Human Rights Watch report found that between 2000 and 2010, more than nine-hundred-and thirty Bangladeshis were killed by border guards along the security wall.⁸⁷ Additionally, laws pertaining to the wall largely protect border guards after such transgressions. Under the Border Security Act, for example, guards cannot be prosecuted in civilian courts unless the federal home ministry gives its permission. However, this is

⁸³ “India Elections: Death Toll Hits 43 After Attacks on Muslims in Assam,” *The Guardian*, May 2, 2014, <http://www.theguardian.com/world/2014/may/07/india-elections-death-toll-43-attacks-muslims-assam>.

⁸⁴ Charlotte Alfred, “Five Reasons Why Narendra Modi Leading India is so controversial,” *The Huffington Post*, May 15, 2014, http://www.huffingtonpost.com/2014/05/15/narendra-modi-views_n_5316284.html.

⁸⁵ Charlotte Alfred, “Five Reasons Why Narendra Modi,” 2014.

⁸⁶ Lisa Friedman, “A Global National Security Issue Lurks at Bangladesh’s Border,” *The New York Times*, March 23, 2009, <http://www.nytimes.com/cwire/2009/03/23/23climatewire-a-global-national-security-issue-lurks-at-ba-10247.html?pagewanted=all>.

⁸⁷ “Trigger Happy,” *Human Rights Watch*, December 9, 2010, <http://www.hrw.org/node/94641/section/3>, 2.

something that, according to the organization, is very rare.⁸⁸ This has led many to believe that some of the guards are killing Bangladeshis simply because of their nationality, and because they don't face any repercussions after killing "unwanted" migrants.

Some Indian citizens are also unhappy about increased numbers of Bangladesh migrants in their country. Part of the reason is that some believe they shouldn't have to give safe harbor, as climate change was largely created by first-world nations, not India. Many also are fearful that these immigrants will take their jobs and disrupt their way of life. The Center for American Progress also explains that India will not be able to absorb too many climate migrants because the country is already very overpopulated, and could have close to 1.6 billion inhabitants by 2050—sparking mass internal migrations within the country.⁸⁹ Clearly, SLR comes with major consequences.

⁸⁸ "Trigger Happy," *Human Rights Watch*, 2010, 2.

⁸⁹ Michale Werz, "Climate change, Migration, and Conflict," *The Center for American Progress*, 2012.

Section Two: SLR Adaptation Efforts in Bangladesh/Miami-Dade County

IX. Adaptation Strategies/Obstacles to Combating SLR in Miami-Dade County:

The first portion of this paper addressed the many problems SLR is causing in Miami-Dade County and Bangladesh. As discussed, SLR has hurt property values, real estate development, and the Everglades in Miami-Dade County, and, in Bangladesh, adversely affected rice fields, health, and the Sundarbans. Additionally, this paper has explored the obstacles Miami-Dade County and Bangladesh face in trying to insure their citizens against sea level impacts, and how external migration is becoming more necessary as a result, especially in Bangladesh. The next section of this paper will discuss the responses at the sub-national and national level that Miami-Dade County and Bangladesh are taking to combat SLR, and the obstacles to such responses.

To confront the consequences of SLR, Miami-Dade County has been proactive at the regional level to adapt. In the last few years, Miami-Dade County has created numerous committees and produced many in-depth reports on SLR and flooding in the county. In 2006, the Board of County Commissioners created the Miami-Dade County Climate Change Advisory Task Force to act as an advisory council on climate change adaptation and mitigation in the county. In its Second Report and Initial Recommendations, presented in 2008 to the Board of County Commissioners, they outlined a variety of ways in which the county could mitigate the damage caused by rising sea levels.

In 2010, four counties in Florida, Miami-Dade, Broward, Palm Beach, and Monroe formed the Southeast Florida Regional Climate Change Compact, which is a “voluntary, broad-based, and growing collaboration of more than two hundred public, private, and civic stakeholders from the four countries.”⁹⁰ Combined, these counties make up more than one hundred cities and represent roughly thirty percent of Florida’s total population.⁹¹ The purpose of the Compact is to pool resources and expertise, and to work together. In 2012, the Compact created a Regional Climate Action Plan for Southeast Florida—outlining one hundred recommendations.⁹²

In 2013, the County created another task force called the Miami-Dade County Sea Level Rise Task Force to specifically assess SLR impacts. In 2014, the task force produced the Miami-Dade Sea Level Rise Task Force Report, which made five main recommendations—accelerate the adaptation planning process, recruit experts to deal with flood protection, build more pumps and salinity structures, and finally, design more resilient roads and bridges.⁹³ In that same year, the Board of County Commissioners adopted Resolution R-451-14, which now requires that all future infrastructures to be built in the county take SLR into account.⁹⁴ Structures that already exist must be evaluated on how SLR will impact them, and what can be done to further adapt them.⁹⁵

⁹⁰ Forbes Tompkins, “Sea Level Rise and it’s Impact on Miami-Dade County,” *World Resources Institute*, accessed January 8, 2015,

http://www.wri.org/sites/default/files/sealevelrise_miami_florida_factsheet_final.pdf, 6.

⁹¹ Miami-Dade County Sea Level Rise Task Force, “Miami-Dade Sea Level Rise Task Force Report and Recommendations,” July 1, 2014,

<http://www.miamidade.gov/planning/library/reports/sea-level-rise-report-recommendations.pdf>, (accessed January 20, 2015).

⁹² *Ibid.*

⁹³ *Ibid.*, 4

⁹⁴ *Ibid.*, 6

⁹⁵ *Ibid.*, 6.

Clearly, at least at the regional level, in setting up committees, drafting reports, and passing resolution R451-14, the county has made strides.

Miami-Dade County also has been taking steps to specifically deal with storm water drainage issues. According to the World Resource Institute, around 70% of the drainage capacity of 28 of southeast Florida's flood control infrastructures could be disrupted with a sea level rise of only 3 to 9 inches.⁹⁶ In Miami Beach, city planners and real estate developers are actually encouraging more beachfront development as they can then use these real estate taxes/fees towards a \$300 million storm-water project.⁹⁷ This is because Florida is one of only a handful of states that does not collect an income tax; therefore, taxing real estate is one of the only ways to collect enough revenue. In order to implement this storm water project, the city has hired a Massachusetts-based firm known as CDM Smith. The goal is to build new sea walls, increase the number of storm drain pumps, reline the pipelines, and put in one-way valves.⁹⁸ The goal is that by 2020, Miami Beach will have eighty more storm drain pumps—capable of collecting and moving up to 14,000 gallons of seawater back into the

⁹⁶ Forbes Tompkins, "Sea Level Rise and it's Impact on Miami-Dade County," *World Resources Institute*, accessed January 8, 2015,

http://www.wri.org/sites/default/files/sealevelrise_miami_florida_factsheet_final.pdf, 3.

⁹⁷ "Miami Beach Pushing Beachfront Development—Collecting Storm-Water Fees to Fight Sea-Level Rise," *Homeland Security News Wire*, January 5, 2015,

<http://www.homelandsecuritynewswire.com/dr20150105-miami-beach-pushing-beachfront-development-collecting-stormwater-fees-to-fight-sealevel-rise>.

⁹⁸ Jeff Goodell, "Why the City of Miami is Doomed to Drown," *Rolling Stone*, June 20, 2013,

<http://www.rollingstone.com/politics/news/why-the-city-of-miami-is-doomed-to-drown-20130620?page=4>.

Biscayne Bay.⁹⁹ However, there has been some criticism of this project, and scientists worry that continued development near the sea is a recipe for disaster.

Evidently, Miami-Dade County has taken steps at the regional level to address SLR, but it is not the only place in the U.S. refocusing its efforts. For instance, at the state level, Georgia, North and South Carolina, and Louisiana have all commissioned reports on SLR and drawn up their own adaptation strategies to deal with the issue.¹⁰⁰ In Louisiana, after Hurricane Katrina, one of the most devastating hurricanes to hit U.S. shores, the Army Corps of engineers worked to improve levees and other structures to reduce the effects of flooding. Additionally, in South Carolina, the state has set up a “40-year setback line,” which ensures that new real estate developments stay as far back from the coast as possible. Only with a special permit can certain developers develop closer to the coastline.¹⁰¹ Unlike these states, the state of Florida itself is unsupportive and uninvolved when it comes to addressing SLR, leaving all the work to the counties.

At the state level, a number of leaders refuse to recognize even the existence of climate change, and, as a result, beachfront development continues unabated. Senator Marco Rubio and Governor Rick Scott have consistently denied the existence of climate change and have not taken the threat of SLR seriously. In March of this year, for example, the Florida Center for Investigative Reporting found that the state’s Department of Environment Protection was being instructed to omit any words related to climate change,

⁹⁹ “Miami Beach Pushing Beachfront Development—Collecting Storm-Water Fees to Fight Sea-Level Rise,” *Homeland Security News Wire*, January 5, 2015, <http://www.homelandsecuritynewswire.com/dr20150105-miami-beach-pushing-beachfront-development-collecting-stormwater-fees-to-fight-sealevel-rise>.

¹⁰⁰ “Adaptation Examples in the Southeast,” *EPA*, 2014, <http://www.epa.gov/climatechange/impacts-adaptation/southeast-adaptation.html>.

¹⁰¹ *Ibid.*

global warming or sea level rise from its reports, emails, and other communications, and that any references to sea level rise should be called “nuisance flooding” instead.¹⁰² This same type of censorship is also occurring in North Carolina, Louisiana, and Tennessee where laws have been passed to keep certain words out of reports/policies, and to allow teachers to suggest alternative theories on climate change.¹⁰³ Due to such widespread dismissiveness of climate change, FEMA has announced that in 2016, it will only offer funds to states that “approve hazard mitigation plans that address climate change.”¹⁰⁴ This may force Florida and the other states mentioned above to rethink their policies.

Despite FEMA’s recent declaration, currently, investments keep flowing into the county. For example, in Miami Beach, over \$128 million was collected in property taxes last year—an increase of \$117 million from just a year prior.¹⁰⁵ Additionally, a new one billion dollar development called Brickell City Center was just constructed in Miami Beach—only a few blocks away from the sea.¹⁰⁶ If this type of development continues, even more businesses and people will be at risk. At some point, Miami-Dade County and other counties along the coast will be unable to bear the costs of implementing sea level rise safeguards, and aid from FEMA and at the state and even national levels will most likely be necessary in the next few years.

¹⁰² Tanya Lewis, “If Florida Censors Climate Change Talk, it’s not Alone,” *The Christian Science Monitor*, March 10, 2015, <http://www.csmonitor.com/Science/2015/0310/If-Florida-censors-climate-change-talk-it-s-not-alone>.

¹⁰³ Ibid.

¹⁰⁴ Katherine Bagley, “FEMA to States: No Climate Planning, No Money,” *insightclimatenews.org*, March 18, 2015, <http://insideclimatenews.org/news/18032015/fema-states-no-climate-planning-no-money>.

¹⁰⁵ “Miami Beach Pushing Beachfront Development,” *Homeland Security News Wire*, 2015.

¹⁰⁶ Jeff Goodell, “Why the City of Miami is Doomed to Drown,” 2013.

X. Adaptation Strategies/Obstacles to Combating SLR in Bangladesh:

In Bangladesh, through planning and research, there have been some successes in trying to counteract the effects of SLR. According to the United Nations Environmental Program (UNEP), Bangladesh spends roughly \$1 billion dollars a year, or 6-7 percent of its annual budget on adaptation.¹⁰⁷ However, the World Bank has estimated that by 2050, the country may need around \$5.7 billion for adaptation.¹⁰⁸ This is a daunting expense for a small third-world country without the resources of places like Miami-Dade County. Nevertheless, the government has been working hard to adapt to the threat of SLR using its own resources and those of many NGOs. In 2009, under the UNFCCC, Bangladesh became one of the first countries to implement a National Adaptation Plan of Action (NAPA).¹⁰⁹ NAPA's are reports that discuss areas LDCs must prioritize with regards to climate change. Bangladesh's NAPA promotes research on droughts, floods, water salinity, and saline-resistant crops and fish species. It also discusses ways to provide affected coastal villages with clean drinking water, how to implement afforestation projects in these areas (as a part of the Green Belt Project), the importance of constructing more flood shelters/buildings on stilts, and lastly, insurance.¹¹⁰

¹⁰⁷ "Bangladesh Uncovers the Crippling Cost of Climate Change," *UNEP News Centre*, May 23, 2014, <http://www.unep.org/newscentre/default.aspx?DocumentID=2788&ArticleID=10864&l=en>.

¹⁰⁸ Ibid.

¹⁰⁹ "Ready or Not: Can Bangladesh Cope with Climate Change," *New Internationalist Magazine*, April 1, 2012, <http://newint.org/features/2012/04/01/climate-adaptation-bangladesh/#comments>.

¹¹⁰ The Ministry of Environment and Forest Government of the People's Republic of Bangladesh, *National Adaptation Programme of Action (NAPA)*, November 2005, <http://unfccc.int/resource/docs/napa/ban01.pdf> (accessed January 31, 2015), xvi.

In 2009, the government created the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). The updated adaptation/mitigation plan outlines six main areas of concern to be explored. These are: food security, social protection, health, disaster management, infrastructure, research and knowledge management, mitigation/low carbon development, and capacity building/institutional strengthening.¹¹¹ The government also has set up an environmental committee, chaired by the Prime Minister that works with members of Parliament to draw up and implement environmental policies. There also is an inter-ministerial committee on climate change run by the Minister for Environment and Forest (MOEF) that also works with various organizations and governmental agencies.¹¹² However, the UNFCCC notes that these organizations are fairly weak and need “substantial improvement.”¹¹³

Through these adaptation plans, climate funds have been allocated and funneled into certain projects. After the creation of the BCCSAP in 2009, the Climate Change Trust Fund (CCTF) was created to help fund 219 government projects related to sea level rise and other climate threats.¹¹⁴ Since the implementation of the BCCSAP, progress has been made. For example, the government has been successful in developing 4,000 km of flood-protected embankments, increasing afforestation in coastal areas, updating

¹¹¹ Government of the People’s Republic of Bangladesh, *Bangladesh Climate Change Strategy and Action Plan*,” September 2009, http://www.moef.gov.bd/climate_change_strategy2009.pdf, (accessed February 15, 2015), xvii-xviii.

¹¹² The Ministry of Environment and Forest Government of the People’s Republic of Bangladesh, *National Adaptation Programme of Action (NAPA)*,” November 2005, <http://unfccc.int/resource/docs/napa/ban01.pdf> (accessed January 31, 2015), 4.

¹¹³ The Ministry of Environment and Forest Government, *National Adaptation Programme of Action*, 2005, 4.

¹¹⁴ “Bangladesh Climate Change Trust (BCCT),” Ministry of Environment and Forests, 2014, <http://www.bcct.gov.bd>.

infrastructure, and creating a saline-tolerant rice crop.¹¹⁵ However, the assessment also reports that effective planning is still lacking, as well as sufficient monitoring, institutional capacity, and funding.¹¹⁶

In 2010, the government created another fund, called the Bangladesh Climate Change Resilience Fund (BCCRF), which has a greater focus on “climate resilience and sustainable growth.” Developed nations such as the U.K. and Denmark, and organizations such as the World Bank and USAID have partnered with the government to provide funding—amounting to \$188 million so far. However, it has not been performing up to par and may be disbanded in 2017 due to the World Bank’s withdrawal.¹¹⁷ Although certain NGOs and international bodies are helping the country, a joint UNDP/UNEP report found that since 2009, the government of Bangladesh has consistently spent over 80% of its climate expenditures on climate-related projects, while international donors and NGOs have contributed less than 20%.¹¹⁸

Unfortunately, there is only so much the government can do without adequate funding. Most adaptation funding, such as in the Green Climate Fund, set up by the UNFCCC, is funneled to larger and more dynamic countries like China and India—

¹¹⁵ Towfiqul Arif, “Bangladesh’s Climate Change Responses and Adaptation Efforts,” August 2013, http://unfccc.int/files/adaptation/groups_committees/ldc_expert_group/application/pdf/bangladesh.pdf.

¹¹⁶ Ibid.

¹¹⁷ “Country Brief: Bangladesh Whole-of-Government Approach to Climate Finance,” *UNDP/UNEP*, October 2014, http://www.climatefinance-developmenteffectiveness.org/archive/documents/Bangladesh_Country_Brief_FINAL_28102014.pdf, 6.

¹¹⁸ Ibid, 8

leaving smaller ones with less to work from.¹¹⁹ Adding to this, other barriers to implementing adaptation strategies include: lack of awareness among policy makers, lack of integration, inadequate tools/equipment, and necessary knowledge to implement certain projects.¹²⁰ Therefore, there is still plenty of work to be done in Bangladesh—and more international donor support is desperately needed.

At the community level, the government and local groups have set up workshops and formed committees to educate discuss adaptation strategies for implementation in Bangladesh. For example, in 2009, Bangladesh held an International Workshop on Community Level Adaptation to Climate Change, which was created by the Bangladesh Centre for Advanced Studies in conjunction with the IIED (Institute for Environment and development).¹²¹ At this workshop, three days of field studies/visits were conducted, and more than 140 participants representing governments, NGOs, development agencies, or research organizations participated in this learning process.¹²² Additionally, an NGO known as CARE, has instituted a project called “Reducing Vulnerability to Climate Change,” in many vulnerable

¹¹⁹ “Ready or Not: Can Bangladesh Cope with Climate Change,” *New Internationalist Magazine*, 2012.

¹²⁰ Government of the People’s Republic of Bangladesh, *Bangladesh Climate Change Strategy and Action Plan*,” 2009, 20.

¹²¹ Government of the People’s Republic of Bangladesh, *Bangladesh Climate Change Strategy and Action Plan*,” September 2009, http://www.moef.gov.bd/climate_change_strategy2009.pdf, (accessed February 15, 2015), xvi.

¹²² “Third International Workshop on Community-Based Adaptation to Climate Change,” *International Institute for Sustainable Development*, 135, no. 2 (2009).

coastal regions in Bangladesh—helping to spread information to smaller communities threatened by sea level rise.¹²³

Unfortunately for Bangladesh, despite all of the time, effort, and expense put into adaptation strategies, funding continues to be a problem, and time is running out for many Bangladeshis who live and work near the coast. The government is known for its tenacity in finding ways to cope with consequences of climate change. The government has repeatedly challenged Western nations to open their borders to Bangladeshi refugees, and has written strongly-worded newspaper/magazine pieces on climate change and the responsibility of first world nations, which have caused most of the global warming in the first place.¹²⁴ The government strongly believes that more could be done by first-world nations to help climate change victims around the world. The final section of this paper will detail how sub-national and national governments like Bangladesh and Miami-Dade County can work together to adapt to SLR.

¹²³ Government of the People’s Republic of Bangladesh, *Bangladesh Climate Change Strategy and Action Plan*,” September 2009, http://www.moef.gov.bd/climate_change_strategy2009.pdf, (accessed February 15, 2015), 21.

¹²⁴ “Ready or Not: Can Bangladesh Cope with Climate Change,” *New Internationalist Magazine*, April 1, 2012, <http://newint.org/features/2012/04/01/climate-adaptation-bangladesh/#comments>.

Section Three: Recommendations to Better Adapt to SLR in Bangladesh/Miami-Dade County Through a Linkage System

XI. International Linkages as an Adaptation Strategy to SLR in Miami-Dade County and Bangladesh:

Miami-Dade County and Bangladesh present two very interesting cases regarding SLR and adaptation. Miami-Dade County is a sub-national government making progress at the regional level, without receiving support at the state or national levels; the other is a nation making progress at the national level, but not as much regionally. In sum, they are the antithesis of each other. Therefore, it would be beneficial for these two regions to work together to reach their adaptation goals. The final section of this paper will discuss a system known as “linkages,” which is the joining together of nations, sub-nationals, and/or other regions to help mitigate the effects of climate change through emission trading schemes. This section also discusses how “linkages” can be modified to not only address mitigation, but also adaptation, and join together efforts in vulnerable regions that could benefit from increased cooperation.

Linkages are partnerships formed between nations, sub-nations, and/or regions with the intention of mitigating the effects of climate change and helping regions meet their emission reduction goals. It is an idea put forth by Daniel Bodansky, Seth Hoedl, Gilbert Metcalf, and Robert Stavins, of the Harvard Project on Climate Agreement. Their paper, “Facilitating Linkage of Heterogeneous Regional, National, and Sub-National Climate Policies Through a Future International Agreement,” introduces the idea of linkages, how it works, its advantages, and how it can be adopted successfully into future climate agreements, such as those that will be drafted at the UN-sponsored Conference of the Parties (COP 21) in Paris this year. While the idea of linkages has been around since 2007, with

the adoption of the Clean Development Mechanism (CDM) into the Kyoto Protocol, their paper takes the idea further and specifically addresses how the upcoming COP meeting can successfully implement far-reaching linkage systems so that more countries and regions will be interested in signing up and committing to mitigation. However, as will be discussed later in the paper, the fight against climate change will be weak unless an equally far-reaching system addressing adaptation is implemented.

Linkages operate in a market-based system, and are mitigation-centric. The official definition is, “a formal recognition by a GHG mitigation program in one jurisdiction of emissions reductions undertaken in another jurisdiction for purposes of complying with the first jurisdiction’s mitigation program.”¹²⁵ Nations, sub-nations, and/or other regions can form partnerships under a regulatory cap and trade system or carbon tax system. They explain that cap and trade is the easiest form of linkage as it “allows firms (emission sources) in one jurisdiction to comply either with local allowances or equivalent allowances from another, linked system.”¹²⁶ Under the Kyoto Protocol, which requires member countries to reduce GHG emissions, three different linkage mechanisms were created: International Emissions Trading, Joint Implementation, and the Clean Development Mechanism (CDM). Each system gives developed nations flexible options under which they can choose meet their emission reduction goals. According to Bodansky et al., as of 2014, “twenty regional, national, or sub-national cap-and-trade systems were either operating or scheduled to launch in 40 countries (not including

¹²⁵ Daniel Bodansky, Seth Hoedl, Gilbert Metcalf, Robert Stavins, “Facilitating Linkage of Heterogeneous Regional, National, and Sub-Nationals Climate Policies Through a Future International Agreement,” *Harvard Project on Climate Agreements*, November 2014, <http://belfercenter.ksg.harvard.edu/files/harvard-ieta-linkage-paper-nov-2014.pdf>, 2.

¹²⁶ *Ibid*, 4.

emissions trading under the Kyoto Protocol).”¹²⁷ Some of these linkage programs include the EU ETS, RGGI, seven regional pilots in China, and some in California, Kazakhstan, New Zealand, Quebec, Switzerland, and Tokyo.”¹²⁸ Evidently, linkages are proving to be a very attractive solution to mitigating GHG emissions.

It is recommended that sub-national entities like Miami-Dade County and national entities like Bangladesh help each other reach their adaptation goals through a linkage system similar to that of the mitigation linkage system. Of course, all areas affected by climate change and SLR should work together to adapt, but in this paper, I will only focus on potential solutions for Miami-Dade County and Bangladesh. Clearly, linkages serve an important function in helping nations mitigate GHG emissions. There are many linkage systems in operation today that are proving to be very successful. While mitigation is extremely important, countries need to start focusing some of their attention on developing adaptation measures. As explained in this paper, the effects of climate change, and especially SLR, are being felt at this very moment in Bangladesh, Miami-Dade County, and many other regions in the world. Miami-Dade County and Bangladesh have made some progress in implementing adaptation policies, but there are still gaps.

In their paper, Bodansky et al. write that linkages provide participants with a variety of benefits. First, by lowering the costs of mitigation, linkages attract many countries that otherwise would not be interested in lowering emissions. The writers explain that this happens because linkages “reduce administrative costs through the sharing of such costs and the avoidance of duplicative services. Making the combined system run more

¹²⁷ Ibid, 11

¹²⁸ Ibid, 13

smoothly can insulate both participating systems from political attacks.”¹²⁹ They go on to explain that linkages also, “allow for voluntary exchanges across systems, and thereby facilitate cost-effectiveness, that is, achievement of the lowest-cost emissions reductions across the set of linked systems, minimizing both the costs for individual countries.”¹³⁰

In addition to lowering costs, linkages also help to facilitate the flow of information, ideas, and data from one region to another—increasing everyone’s knowledge on how best to reduce emissions.¹³¹ Furthermore, linkages improve the image of nations, sub-nations, and/or regions, while still allowing for some flexibility in how they want to go about pursuing their emission reduction objectives. Bodansky et al. explain that linkages allow for flexibility because participants can, “pursue the domestic policy instrument that is most feasible politically, while retaining the option to link with other types of systems.”¹³² Additionally, developed countries, hoping to meet their emission reduction goals, may seek out less developed nations and incentivize them to get involved.¹³³

Bodansky et al. prescribe what must be included in the 2015 agreement at COP 21 to ensure the linkage system operates as effectively as possible. First, they argue that the new agreement must include formally agreed upon definitions of key terms and units so that all participants are aware of exactly what linkage entails.¹³⁴ Parties at the COP must agree to a monitoring/regulatory system (most likely the UNFCCC) that will track progress and effectiveness amongst participants, and ensure all parties know what is

¹²⁹ Ibid, 6

¹³⁰ Ibid, 5

¹³¹ Ibid, 22

¹³² Ibid, 11

¹³³ Ibid, 16

¹³⁴ Ibid, 29

expected of them.¹³⁵ However, despite the importance of making rules, Bodansky et al. believe that there still needs to be flexibility in the agreement so that participants feel free to try new solutions and opt out of others. Ideally, the system will help participants figure out what mitigation strategy works best for them, and be able to change their strategy if need be. Therefore, linkage combines a top-down and bottom-up approach in that the UNFCCC regulates, sets rules, and monitors, but participants are able to choose how they want to meet their emission reduction goals in a way that politically and financially works best for them.

In order for regions such as Bangladesh and Miami-Dade County to be able to work together, it would be wise for parties attending the Paris COP meeting this year to consider a future agreement that lays out rules and expectations for an adaptation-centered linkage system. Bangladesh, while proactive in its actions to fight SLR, severely lacks the necessary funding to effectively respond to the problem. Bangladesh has also, historically, spoken of its belief that developed/first world nations must be held responsible for climate change, and must be forced to help LDCs (least developed countries) through funding. As we have seen with the CDM (and countless other mitigation-centered linkage programs) cooperation can be extremely helpful. Although Miami-Dade County is a sub-national region, it is in a much better financial situation than Bangladesh, and the county has technological expertise that can potentially be transferred to Bangladesh. Unfortunately, there is a general lack of action in the United States, even on the mitigation side, when it comes to these international linkages. This is because the United States has never officially ratified the Kyoto Protocol.

¹³⁵ Ibid, 29

This has not precluded activity at the subnational level, however. The state of California, for example, has been working with Canada to reduce emissions showing that small-scale cooperation between a sub-national government and a national government is possible even if the United States is not interested. Ideally, parties under the UNFCCC in Paris this year will be drafting up an entirely new and improved climate agreement to address mitigation and adaptation. Hopefully, the GCF, the largest fund of its kind, established in 2010 under the UNFCCC to pool funds from developed nations for mitigation/adaptation, will be modified so that more funding goes towards adaptation. If these changes happen, a lot more progress could occur.

The best way Miami-Dade County can help Bangladesh is by providing some funding for projects and technological expertise. Some of the biggest projects that Bangladesh needs help in undertaking are mangrove planting, desalinizing water, improving/elevating infrastructure, building storm drainage systems, increasing research on saline-resistant crops, and improving effective rainwater harvesting. Miami-Dade County, with its technological expertise, especially in building better storm drainage systems, (as mentioned earlier in the paper) can really help Bangladesh implement more programs at the regional level—where help is needed most. While this is beneficial for Bangladesh, some might wonder what Miami-Dade County will receive in return for its efforts. This is where the new adaptation linkage system would come into play. Unlike under the Kyoto Protocol, Miami-Dade County and other potential participants would not need to receive credits to further pollute, or in this case, to not adapt. All regions involved will be facing their own issues and will want to adapt immediately. Therefore, instead of receiving emission credits, as under the mitigation system, developed regions can receive

compensation from something the GCF, which then can be used for their own adaptation uses. Therefore, it creates a cycle of aid that is directed specifically towards adaptation to climate change impacts.

XII. Conclusion:

As evidenced in this paper, SLR poses a major threat to Miami-Dade County and Bangladesh, and efforts to lessen its dangerous impact on these regions must be expanded. The best way to mitigate and adapt to the impact of climate change is for nations, sub-nations, and regions to come to each other's aid. No region in the world is fully equipped to deal with the havoc climate change and SLR will wreak on their coasts. Even if all the countries in the world agreed to cut their emissions in half this week, the effects of GHG emissions would still be felt decades later. This is what makes adaptation and especially cooperative adaptation so vital. Where one region lacks money, another has some to spare. Where one region lacks technological expertise, another region has an abundance of it. To those regions without funds, like LDCs, the GCF can serve an even more important role by acting as a subsidy, compensating developed nations for their actions to help others adapt to climate change. Ultimately, every part of the world will feel the impacts of climate change and SLR in some way. In the words of Ban Ki Moon, "climate change does not respect border; it does not respect who you are-rich and poor, small and big. Therefore, this is what we call global challenges, which require global solidarity."¹³⁶

¹³⁶ "Climate Change Quotes," BrainyQuote, http://www.brainyquote.com/quotes/keywords/climate_change.html.

Glossary of Terms:

Acronym	Meaning	Definition
BCCRF	Bangladesh Climate Change Resilience Fund	A fund developed by the government of Bangladesh and the World Bank to fight climate change
BCCSAP	Bangladesh Climate Change Strategy and Action Plan	A more comprehensive version of Bangladesh's NAPA. Outlines six critical pillars that must be addressed by the gov. to address climate change
BCCTF	Bangladesh Climate Change Trust Fund	A fund created under the BCCSAP. Receives funds only from the government of Bangladesh
CDM	Clean Development Mechanism	Emissions trading scheme under the Kyoto Protocol
COP	Conference of the Parties	The decision-making body of an international conference or convention
GCF	Green Climate Fund	A fund under the UNFCCC that developed nations contribute to in order to help developing nations with mitigation//adaptation projects
GRACE	Gravity Recovery and Climate Experiment	Two NASA satellites that take measurements of Earth's gravity field
EU ETS	The European Union Emissions Trading System	An emission-trading scheme set up under the European Union. Currently, the first and largest emissions trading scheme in the world
IPCC	Intergovernmental Panel on Climate Change	An intergovernmental construct under the UN, which produces reports produced by the UNFCCC
LDC's	Least Developed Countries	Countries that rank the lowest on the Human Development Index. There are 48 current LDCs the UN recognizes
NAPA	National Adaptation Program of Action	Outlines strategies least developed countries will employ to adapt to climate change threats
RGGI	Regional Greenhouse Gas Initiative	A partnership between states and provinces in Northeastern parts of the U.S. and Canada to reduce greenhouse gas emissions
SWOT	Surface Water and Ocean Topography	A mission developed by NASA with the intention of producing satellite imagery of the Earth's surface water
UNDP	United Nations Development Programme	A UN sponsored program to help LDCs develop
UNEP	United Nations Environment Programme	A UN sponsored program to address environmental issues in LDCs
UNFCCC	United Nations Framework Convention on Climate Change	An international treaty developed in 1992 to reduce human-created GHG emissions in the world

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