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The Global Effects of Rising Sea Levels on Cities: Venice, Houston, NYC

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The Global Effects of Rising Sea Levels on Cities:

Venice, Houston, NYC

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ABSTRACT

A large majority of the large cities in the United States and in the world are located on the coast because of a human desire to be located near water for a number of reasons. Bodies of water provide both transportation and leisure activities. However, as the climate warms, the polar ice caps are melting and creating a new problem. Sea levels are rising and causing problems with weather and climate in these heavily populated coastal cities.

Using climate science and IPCC data and reports on climate change, my thesis highlights the issue of rising sea levels at hand. It also examines environmental history of climate and weather in selected coastal cities in both the United States and Europe, including Houston, Venice, New York City. It discusses the environmental politics of the potential solutions to this environmental problem and how the issues are handled differently in Europe and the United States. It also draws on how other nations such as the Netherlands have been able to combat this issue through solutions such as the Delta Works system. Finally I look at environmental design solutions and how cities can be restructured to protect themselves from the threat at hand, using the Delta Works as inspiration. This was all be done by using scientific data and history to highlight a problem, and then discussing political issues with the problem's resolution, as well as new design ideas for fixing these cities' problems.

INTRODUCTION: RISING SEA LEVEL IS A GLOBAL ISSUE

Most humans don't typically have interactions with the polar ice caps, so why should it matter if they're melting? Well, as the ice melts, the water goes somewhere, and that is into the oceans that flow through the entire planet. This causes a rise in sea level. So many human civilizations have built cities along the coasts, and for quality reasons. Access to water enables travel and trade via ships, boats and ferries. Water enables leisure in the form of beaches, swimming, kayaking, paddle boating, and so many other activities. Human beings have a desire to be near the water and have built so many large cities on coasts on all six habitable continents.

However before humans knew what was happening, they caused their own problem. Climate change is widely believed to be anthropogenic, or caused by human activity. As humans in the industrial age have lived, built and worked in these cities, and in other locations, they have emitted greenhouse gases that have caused our global climate to slowly warm. Though there are many effects of climate change, this paper examines how a warming climate affects rising sea level and human life.

When the climate warms, the planet's surface warms. This warming occurs not only on land, but also in our oceans that cover the majority of the planet. Warming oceans lead to melting ice, which leads to the higher sea levels we are experiencing. When weather phenomena such as hurricanes, tsunamis and

thunderstorms occur in our cities, these higher sea levels urge on more devastating results such as floods.

Rising sea levels is a global issue and I have selected three cities to examine thoroughly as examples of the effects the sea level has on urban populations. For each of the three cities, I have examined how their environmental history has shaped the issue of rising sea level today. I then examined how politics can help or hurt cities trying to combat climate change related issues. Finally I have looked at how each city is utilizing environmental design to actively change the region and protect its people and infrastructure.

The three cities explored are Houston, Venice and New York City. Two American cities were selected because they exhibit how two cities of the same country can differ in their policies toward climate change based on the different political interests in each area. I grew up in Texas and attended college in the Bronx, so I wanted to compare how different my environments have been throughout my life. I also chose Venice to give a classic example of a non-American city that has long battled flooding, yet is still attempting to combat the issue. I also briefly explore the environmental design of a long completed system in the Netherlands and how this country's design has influenced other nations to carry out similar projects. Finally my research concludes with my own additional policy recommendations that are applicable globally and in individual cities.

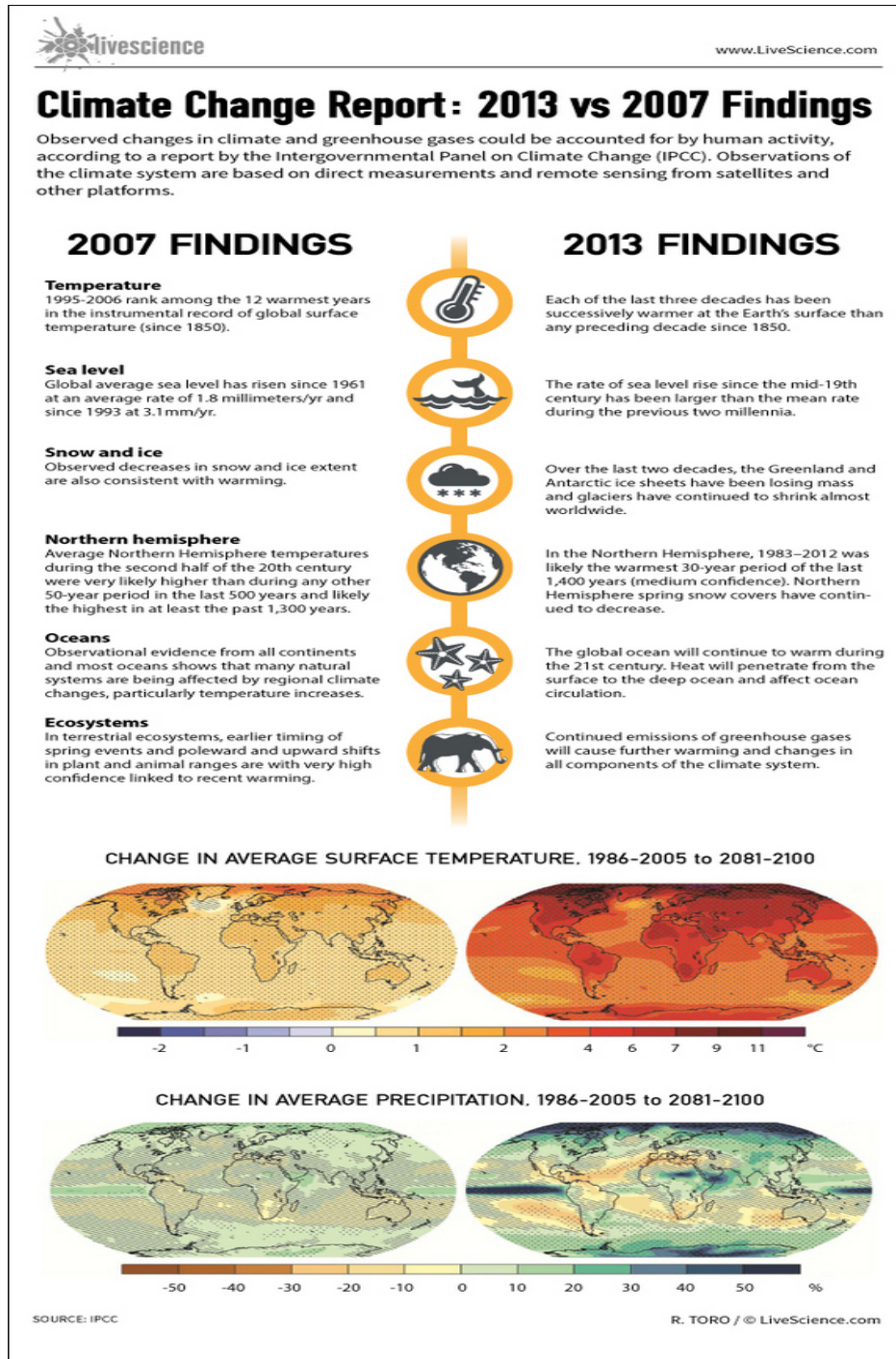
1. SCIENTIFIC ANALYSIS OF THE PROBLEM

1A. The IPCC Climate Change Assessment Report

The Intergovernmental Panel on Climate Change released their Fifth Assessment Report in 2013. The main goal of the IPCC's reports is to gather all of the best research on climate change in one place for the public to read and comprehend. It compiles scientific research and information on climate change, the impact climate change has on our weather and natural society, and suggestions for how to approach climate change mitigation through environmental policies.

The IPCC's Fourth Assessment Report was released seven years before it's successor. The 2013 assessment report supports the findings of the 2007 report, indicating that the problems have continued throughout time as expected, as shown below (see figure 1). Both reports conclude that rising sea level and other climate change issues are the results of human behavior.

Figure 1: Comparison of 2013 and 2007 IPCC Assessment Reports



Source: Toro, Ross. Chart. 2013, *Global Warming Evidence: 2007 Report Compared to 2013*. <http://www.livescience.com/40019-global-warming-evidence-2007-report->

[compared-to-2013-infographic.html](#). Web. 30 April 2014.

1B. Climate Science Defined and Rising Sea Levels

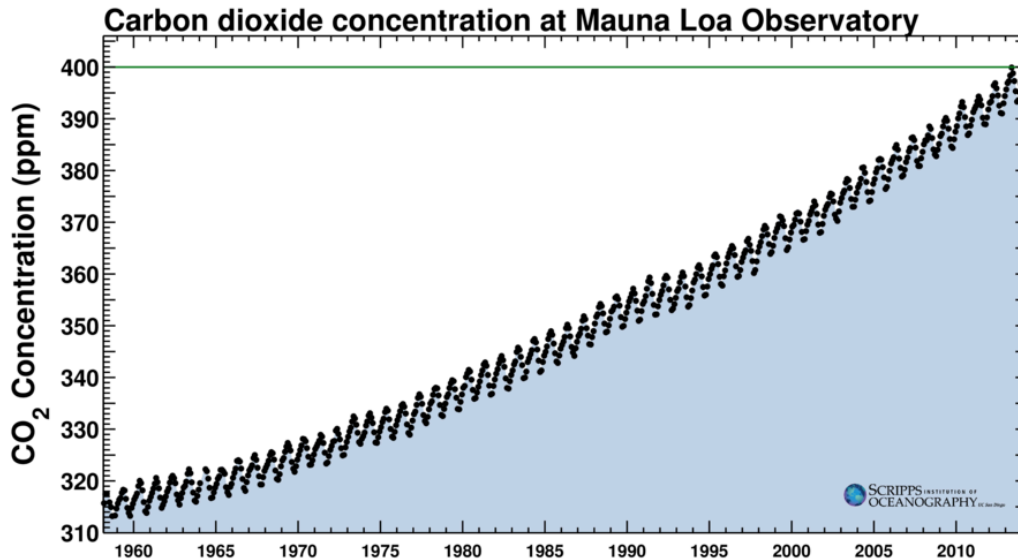
The Earth's climate is a dynamic system resulting from the combined interaction of various parts of Earth with each other and with the Sun. These various parts consist of the atmosphere, the hydrosphere, the cryosphere (glaciers, terrestrial ice sheets, and sea ice), the biosphere and the lithosphere. These smaller systems work together to form our larger climate system (Mathez 2). When anything changes in one of the smaller systems, it results in a change to the larger encompassing system. This is what we call climate change.

Climate change can be measured by amounts of carbon dioxide emissions. The carbon cycle plays a role in the overall climate system. The exchange of carbon throughout the atmosphere, ocean and biosphere is the most important chemical interaction in Earth's climate system (Mathez 3). All of Earth's carbon is stored in these reservoirs. In the atmosphere, the carbon cycle is affected by photosynthesis of plants and decay of organic material that release carbon dioxide into the atmosphere daily. Long term, the ocean plays a large role in the carbon cycle. There is more than 50 times the amount of carbon in the ocean than in the atmosphere. More than 99.9 percent of carbon on Earth exists deep in the lithosphere in the form of rocks (Mathez 4). The carbon cycle is crucial to our climate's natural function,

however excess greenhouse gas emissions from human behavior are causing our climate to change.

Greenhouse gas buildup is in the form of carbon dioxide, methane, ozone and water vapor, and these gases reside in the troposphere, the lower part of the atmosphere where weather occurs. These gases absorb heat radiated from the surface of the planet and act to warm the surface. These gases have been building up since the beginning of the human industrial age, and measurement began in 1958. The measurements were taken from the top of Mauna Loa, a volcano in Hawaii. From 1958 until the early 2000s, the measurements formed a curve with a positive slope, showing how carbon dioxide concentration has increased constantly. A seasonal variation is shown by the zigzagging pattern. This reflects the life cycle of plants in the Northern hemisphere. More plants are alive in May (the upper peaks) and less plant life occurs in October (the lower peaks), therefore emissions are higher and lower respectively in these months as plants are emitters of carbon dioxide. This curve is known as the Keeling curve and is demonstrated below (see figure 2).

Figure 2: The Keeling Curve



Source: *The Keeling Curve*. Graph. 2014, *The Keeling Curve*.

<http://keelingcurve.ucsd.edu/>. Web. 7 May 2014.

The warming of the Earth's surface levels affects rising sea level by melting ice. This is not something many human beings directly observe. There are not large human populations in regions with permanent ice and snow coverage. In some latitudes ice and snow are only seen seasonally, and in others they are not experienced at any point in the year. But as the surface temperatures of the Earth increase, permanent ice melts and seasonal snow patterns have changed. Snow days declined by 20 to 60 percent in the late 1980s. This reduction in snowfall coincided with an upward shift in average winter temperatures (Pollack 194-96). As

permanent ice caps in the Polar Regions diminish, they melt into water that is added to our ocean. As the ocean carries more water, the sea levels rise globally.

Sea level is currently rising at a rate of 0.1 inches per year, or 10 inches per century. The IPCC's 2007 report estimates that by the year 2100, it could be between 8 and 24 inches higher than its current level (Mathez 9). This is all due to the melting of glaciers and thermal expansion of the ocean that results. Because warm water is less dense than cold water, it takes up more space.

How does all of this data affect our cities around the globe? Two-thirds of cities with populations greater than 5 million people are located on coasts and are therefore vulnerable to the effects of rising sea level. To give one example, in China, a sea level rise of just 20 inches would affect regions within 33 feet of the present sea level. Currently, this region is home to 144 million people and 11 percent of China's population. Given worldwide migration trends to cities, these numbers will only have increased by 2100, the year sea levels are estimated to have risen up to 24 inches (Mathez).

1C. Flood Warning: The Science of Weather

There is a distinction between weather and climate. Weather refers to the conditions of the atmosphere at any one given time (Mathez 1). Weather systems form and decay over a period of days, and weeks at the longest, and on continent-

wide scales. Climate is the average weather patterns for a region over some time, and also includes the entire globe.

Though the cities I have researched are located in completely different regions around the globe, their weather patterns have all been affected by global climate change. Rising sea level has affect each city by changing its weather patterns. As the water rises, cities become more susceptible to coastal flooding from storms that can affect the infrastructure and homes of many residents in the large populations. Coastal flooding from hurricanes, thunderstorms and tsunamis can increase in intensity, length and frequency.

Hurricanes are just one type of weather phenomena that can affect coastal cities. Sea surface temperatures have risen as a result of general surface temperature rise associated with climate change. Data shows there is a significant correlation between sea surface temperature and hurricane intensity. The warmer the sea surface is, the stronger the storm. Sea surface temperatures alone can explain an average of 55 percent of the changes that occurred in a simulated hurricane intensity experiment (Michaels 74). Higher carbon dioxide levels result in higher sea surface temperatures, which lead to stronger tropical cyclones. These cyclones lead to the flooding that was experienced in New York City during Hurricane Sandy. Research models “consistently indicate that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift towards stronger storms, with intensity increases of 2-11% by 2100” (Samenow). The

melting of the Arctic sea ice has led to these conclusions on the nature of flooding along global coasts, and makes coastal cities vulnerable to the damages from the impact of the storms.

Rising surface temperatures affect cities more so than other non-urban areas. This is as a result of the urban heat island effect, which affects the sea surface temperature in addition to the effects already caused by climate change patterns. The urban heat island effect has caused a rising sea surface temperature in coastal regions, for example, Venice. Research teams at the University of Southampton have revealed that the sea surface temperature “in coastal regions is rising as much as ten times faster than the global average of 0.13 degrees per decade” (“University of Southampton”). The urban heat island effect is a process where industrial, urban areas produce large amounts of heat that make the area warmer than other non-urban areas, having extreme consequences. In Venice, the heat island effect strongly affects the economy. The Venetian economy relies on the fishing industry. A rise in the sea surface temperature in the Venetian lagoon reduces oxygen levels and displaces fish nursery grounds, causing low viability in the fish that fuel the industry (“University of Southampton”).

Given all the scientific data gathered from the IPCC’s various Assessment Reports, cities and governments worldwide must find solutions to protect their cities, people and infrastructure from damaging waters from floods and stronger storm surges. Anthropogenic behavior in today’s Anthropocene has caused climate

change problems worldwide, and now we must tackle the issues we have presented ourselves with throughout the years.

2. ENVIRONMENTAL HISTORY

2A. A History of Sea Ice

The history of sea ice is a very important one in the area of environmental history. While I will examine the individual environmental histories of each of the three cities I explore in my research, I first must note the importance of ice on a global scale. The sea ice located just in the Arctic Ocean for example, affects cities globally, though located in a remote area with little human life. Ice contributes to the biodiversity of the planet. Antarctica is an entire icy continent with its own species. Ice is an important part of our planet's overall functioning climate.

Sea ice occurs in the oceans as one moves closer to the poles, where the temperature at sea level approaches freezing and the ocean becomes solid. Seawater actually freezes at a slightly lower temperature than freshwater due to its salt content. The annual sea ice that forms and breaks each year seasonally is about three feet thick currently. During the winter seasons, Antarctica actually doubles in area as the ocean freezes. Sea ice drifts, and has caused trouble with sea navigation for centuries (Pollack 35-66).

Historically, sea ice once covered almost the entirety of the Arctic Ocean in the winter season, and about a third of the ice melted in the summer season. In the 1980s and 1990s, the summer melting began to consume more amounts of ice, until by the end of the century the summer sea ice extended only over 75 percent of the area it had once covered in the middle of the 20th century. The perennial ice that had

normally survived the summer melting was diminishing at a rate of 10 percent per decade. The average thickness of Arctic sea ice at the end of the 20th century was half of what it was mid-century. There is a very real possibility that the Arctic Ocean may cease to have ice at all during the summertime within a few decades, given current sea ice loss projections (Pollack 206-09).

Around 120,000-20,000 years ago, ice covered far more of the Earth's surface than it does today. At its maximum extent, ice covered all of Canada, Greenland, Iceland, Scandinavia, as well as most of the British Isles, Germany, Poland, and Russia. In the United States, it extended as far south as today's Missouri and Ohio rivers and east throughout New England. There were glaciers in the Rocky Mountains and Sierra Nevada. There was extensive ice in the Andes of southern South America and on mountain peaks in Africa as well. Sea ice permanently covered the entire Arctic Ocean as far south as Iceland. It extended into the Bering Sea between Russia and Alaska. The world as we know it today is nothing like this, and in the future will change even more as a result of climate change effects from the Anthropocene (Pollack 67-69).

The maximum spread of the continental ice sheets throughout North America and Europe ended 20,000 years ago, when the ice began to melt. This melting was a result of a warming climate over the next 10,000-12,000 years. Earth's average surface temperatures were increased by fifteen to twenty degrees Fahrenheit. There were natural periods of warming and cooling that followed. Thermometer readings

over 150 years have showed that the Earth's surface has on average warmed about 1.8 degrees Fahrenheit (Pollack 103). This trend has accelerated since then. Over the last 25 years of record, the warming occurred four times quicker than the 150-year average. As humans move this planet further into the Anthropocene, the sea ice will continue to melt and drive us further into roadblocks such as rapidly rising sea level.

2B. Environmental History of Venice, Italy

Venice, Italy is a coastal city losing land area due to rising sea level. It is located in a low-lying area on poor foundation. Venice is one of the most notable sinking cities in the world and has been sinking for centuries. The city is located on the Venetian Lagoon on the Adriatic Sea. It was founded around sixteen hundred years ago and the sea level in the Adriatic Sea has risen almost six feet since. Venice has suffered flooding for centuries and the floods were dealt with in the short-term throughout history. The acknowledgement of climate change possibly strengthening the flooding in the 20th century has led the Venetian government to search for a long-term plan to save the historic city before it is complete submerged underwater (Pannone).

Venice has been sinking for centuries due to its location in a water-dominated environment, where lagoon sediments settling naturally and the pumping of freshwater from an aquifer deep below the city have contributed to the

city's sinking for centuries. The Venetian Lagoon experiences a weather phenomenon called acqua alta or "high water". These high waters are the result of storm-driven tides, and have been increasingly higher as time goes on (Pannone). The tide must rise above 100 centimeters to be classified as acqua alta, and this high tide occurs about four times a year on average. The Institute of Marine Sciences in Venice predicts that due to rising sea levels, the high waters could swamp the city between 30 and 250 times a year by the end of the 21st century (Barley).

Short-term solutions to the high waters in the past centuries have been to take cover on higher ground and wait it out, demolishing old buildings and building new taller ones, and raising the entrances to buildings. As Venice transformed from a mercantile republic into a historical city that attracted a high volume of tourism, preserving historic buildings, rather than tearing them down, became important to city officials. When scientists started believing global warming was the cause of the rising sea level threatening Venice, Venetian officials began looking for long-term solutions to preserve the city (Pannone).

2C. Environmental History of Houston, Texas

Houston, Texas is a large sprawling city located on the Gulf Coast in the United States. The city has been plagued with environmental issues due to its foundation on low-lying, swamp-like lands. The city's nickname is the Bayou City because of its foundation on swamp and marsh lands, which causes it to have

draining issues during storms, contributing to flooding. The recent rise in sea levels has worsened this problem, just as it has worsened Venice's conditions. While both cities have structural issues that are worsened by rising and warming sea levels and are susceptible to dangerous flooding, the government in Venice has taken more action than the Houston government has done.

Like Venice, Houston's water foundation has led to its initial sinking, before climate change was an addressed issue. Many parts of Houston have swamp foundations, just as Venice has a lagoon foundation. A large section of northwestern Harris County in Houston is sinking rapidly and faces the largest danger from rising sea level threats. Some points in the Jersey Village neighborhood of northwestern Houston are subsiding by up to 2 inches per year. The sinking region of Jersey Village consists of an area of about 18 square miles. Houston's Brownwood neighborhood was first developed as a residential area in the 1930s, with ground elevation 10 feet above sea level. By the 1970s, the neighborhood sat around a foot and a half above sea level and was victim to frequent flooding.

Unlike Venice, Houston is only sinking rapidly in certain areas rather than the entire city being submerged by the rising sea levels. Sitting on the Gulf Coast, Houston's major problem is not associated with high tides, but with tropical storms instead. Houston is victim to hurricanes. Hurricane Alicia destroyed the Brownwood neighborhood completely in 1983 and it was transformed into the Baytown Nature

Center (Merkl). Scientific data has shown that something must be done to save other Houston neighborhoods from disappearing like Brownwood once did.

Galveston Island is a 27-mile long urban barrier island located just outside of Houston along the Texas Coast. It has been long predicted that Galveston will eventually sink just like its neighbor Houston if preventive action is not taken. In 2007, it was anticipated that Galveston had 60 years before anticipated rising sea levels covered the coastal highway on the west side of the island. As of 2013, this estimate was proved wrong as the sea levels are rising faster now than geologists thought five years ago. Galveston is victim to subsidence, meaning it is sinking faster than most other areas in the country. Loss of protective wetlands is rapidly occurring, which means the island will shrink even faster. It is now estimated to shrink by one-third its current size within the next 30 years (Rice). Galveston city officials need to take the threat to the island seriously, as past estimates have been overly optimistic.

2D. Environmental History of New York City

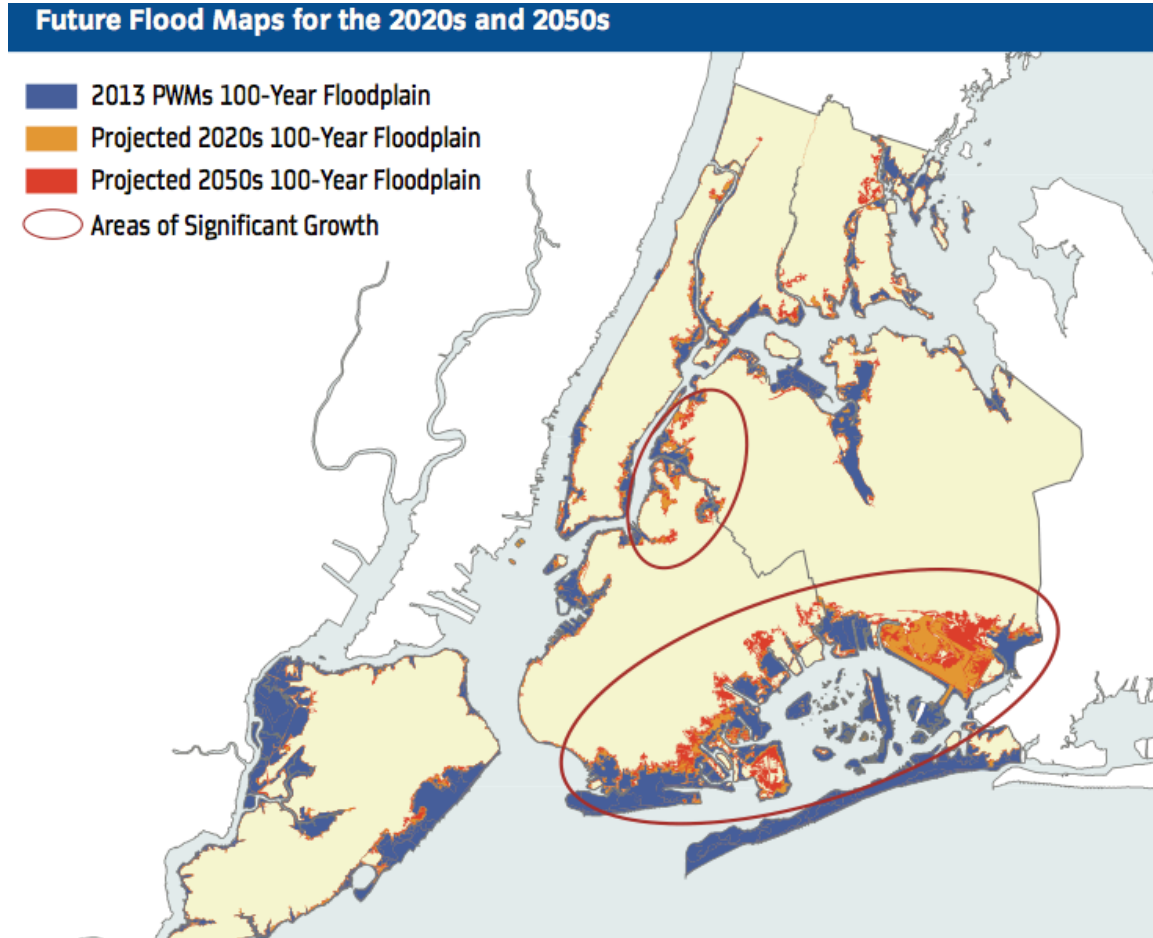
New York City is located on the coast, and its 520-mile coastline has been an essential component of the city's life throughout its environmental history. Before the city was settled in 1609, New York Harbor was littered with archipelagos of small islands, wetlands, beaches and abundant food sources for the early settlement of New Amsterdam. Today's coastline is just as important to the modern-day city

residents. They rely on the coast and waterfront for shipping, entertainment, housing and ferry transportation between the city's islands. The coastline and beaches of New York City are important to many residents (Bloomberg).

In 2012, New York City and the surrounding area received its biggest wakeup call alerting the population about rising sea levels and the real life dangers it can cause. On October 29, 2012, Superstorm Sandy wreaked havoc on the East Coast. The storm's winds peaked at 140 miles per hour and the flooding it caused brought about 148 deaths and \$68 billion in damages. There were utility outages in 17 states and the storm was the largest in Atlantic storm history (Reed).

What was Sandy's role in New York City's environmental history? The storm came with a strongly charged storm surge. A storm surge is the increase in water levels brought by the low pressure and wind field of a coastal storm. When the surge hits the shore, it pushes extra water ashore and floods large areas of land. Because New York Harbor is surrounded by land, it serves as a funnel when a storm surge hits, furthering the damage. Neighborhoods and tunnels for subways and cars were flooded and ocean waves of over 30 feet were measured on the Rockaway Peninsula. Up to 3 million cubic yards of sand on beaches were lost throughout the city (Bloomberg 42-43). Sea level is projected to continue to rise over the next few decades into many neighborhoods and the projections are pictured below (see figure 3).

Figure 3: Projected Sea Level Rise Through the 2050s: NYC



Source: Bloomberg, Michael R. "Coastal Protection." *A Stronger, More Resilient New York*. New York, NY: The City of New York, 2013. 45. Print.

3. ENVIRONMENTAL POLITICS

3A. Political Instability in Venice Halts Progress

The Italian government is not consistent and has slowed down progress in Venice for many years. “It is a political reality in Italy that governments do not last long; 58 governments have come and gone since 1945” (Pannone). A government that is constantly changing has a more difficult time making progress and agreeing on issues such as combating climate change and the flooding of cities. If a new administration doesn’t support legislation to halt the sinking of Venice, success is hard to achieve. Venice’s current design solution project, which will be discussed later, is Project MOSE. This project for example, took a decade to begin construction, yet is still a controversial project. Without consistency in government, public policy faces many challenges in making progress.

3B. Houston City Government Faced With Brunt of Storm Issues

One of the most recent and devastating hurricanes to hit the city of Houston was Hurricane Ike in 2008. In the aftermath of Hurricane Ike, Texas Climate News posted an article posing the question of “whether Hurricane Ike, which roared across the upper Texas coast in September ... will combine with the memory of other recent storms in Texas and Louisiana to help propel Texans toward new ways of thinking and behaving with regard to climate change and sustainability” (Dawson). In the 2009 session of the Texas State Legislature, Texans saw some

interest in taking bipartisan action based on scientific climate change data. The Democratic Party had just won control of both houses in United States' Congress and pledged dramatic climate action at the time. However, the economic crisis in 2009 halted the Texas State Legislature from meeting the climate change action expectations (Dawson).

Hurricane Ike did result in two still-pending proposals to limit damage to the Houston metropolitan area and the entire Texas Gulf Coast from future hurricanes and their storm surges. The first proposal was conceived by a professor at Texas A&M University-Galveston, and consisted of building a surge-blocking network of structures (Dawson). This project proposal is called the Ike Dike, and will be discussed later in chapter 4. The proposed Ike Dike would be a coastal barrier that protects the Houston-Galveston region from hurricane storm surge. The project supporters estimate that a future storm as intense as Katrina could "cause aggregate losses to Texas economy of \$73 billion in gross product, \$61.3 billion in income and 863,000 jobs" and the "economic damage to the United States would be nationally serious" ("About Ike Dike"). The Governor's Commission on Recovery and Renewal reviewed the proposal and recommended that the six counties of the Houston region form a delegation that would deal with the storm surge and regional recovery strategies. This put the task in the Houston city government's hands and out of the state's hands, and the project proposal has yet to pass.

The second still-pending proposal to limit damage to the Houston metropolitan area was to use coastal wetlands to act as a buffer to storm surges. The Lone Star Coast National Recreation Area has been proposed as a wetland to serve as the buffer. The proposal states that the surge protection would “create a 130 mile long area from High Island to Matagorda Island that would both utilize coastal wetlands as a natural storm surge barrier and act as an economic engine for ecotourism” (Dawson). The problem with this proposal is that studies have shown that coastal wetlands cannot significantly suppress major hurricane storm surges, especially with the rising threat of stronger hurricanes in the future due to climate change.

In 2007 when the first geohazard report on Galveston was released, the Galveston City Council dismissed the report because the city manager at the time denied rising sea levels. The current city manager, Michael Kovacs, acknowledges that regardless of the causes of climate change, the sea levels are rising and the island is at risk. Kovacs supports an aggressive coastal management plan and shoreline protection program, emphasizing dune and beach restoration. Much of Kovacs’ focus is on preventing devastation caused by the storm surge of Hurricane Ike in 2008. Kovacs supports the Ike Dike and has donated \$250,000 of Galveston’s money toward the proposed project. The Ike Dike would shield Galveston Island and the entrance to Galveston Bay (Rice).

The globalization of environmental policy issues and the decentralization of policy responsibilities to local governments are two problems that affect climate change legislation in many cities around the world, including Houston, Venice and New York City. While environmental policy issues are worldwide, many national and state governments are putting responsibility for these issues on city governments (Corburn 413). This is problematic in Houston because the city has been left alone in making all decisions related to climate change and sinking prevention. The Texas state government is not playing a part in the environmental policy of its largest city. Texas is not one of the 27 states with climate change action plans, while Houston is one of the 15 United States' cities with populations greater than 500,000 that are members of the Cities for Climate Protection Campaign (Wheeler 483). Houston may be aware of the flooding dangers it is in, but the issue is too large in scale for the city to handle alone without state aid.

3C. PlaNYC: Mayor Bloomberg's Climate Solution

In 2007, then New York City Mayor Michael Bloomberg released PlaNYC, an effort to accomplish a number of goals for the city's one million plus residents. His document initiative targeted ten specific areas of interest including, housing and neighborhoods, parks and public spaces, brownfields, waterways, water supply, transportation, energy, air quality, solid waste and climate change. A number of his target areas involve environmental policy, and Bloomberg's government can be

described as a more environmentally conscious one than that of the city of Houston. Though both are cities of the same nation, it is important to note how greatly priorities differ between cities across the country. Environmental politics play a bigger role in different regions depending on political interests. For reasons such as these, it might be better for the United States to try to unify environmental policy better nationwide, rather than leave cities to deal with problems individually. It can be seen that they have very different goals in mind when handling storm and flooding issues.

PlaNYC claims that cities are both a cause and effect of climate change. Urban areas are estimated to be the cause of about 80% of global greenhouse gas emissions. They are also an effect because so many of them are located on coasts, where citizens are at risk for climate change's dangerous results, such as rising sea level and flooding. Because they are a cause of the problem and are forced to deal with the problem first-hand, Bloomberg's administration says it is the cities' responsibility to combat climate change itself. New York City in particular experiences heat waves, snow storms, storm surges and now even hurricanes, and climate change will only cause more frequent and severe weather patterns such as these ("PlaNYC").

The climate change section of PlaNYC is an interesting one because Mayor Bloomberg notes that according to a study done by his office, the city's municipal buildings account for nearly 3.8 million metric tons of greenhouse gas emissions per

year. One of the central goals of the entire PlaNYC is to reduce these greenhouse gas emissions by 30 percent by 2017. The other goal of the climate change section is to increase the resilience of the city's communities, natural systems and infrastructure to climate risks. One of these climate risks of course is rising sea level, and is addressed in chapter 4 on environmental design ("PlaNYC").

3D. Cities Left Alone With the Issues

While the United States does have an Environmental Protection Agency, its legislation does not address every area of policy for each city in the nation. Not all cities are capable of addressing their environmental issues without state or federal assistance and intervention, and this has led to a lot of inaction and funding issues in Houston and New York City. Though the Italian national government has worked with Venice to pass environmental policy legislation, the constantly changing government has made it difficult to pass laws. Local governments know their cities the best and should have primary responsibilities in enacting environmental policy legislation, but the federal government should work with them and set standards for every city to follow as well. Without cooperative legislation on both parts, it will remain difficult to enact any policies.

3E. Climate Skepticism and Political Interests Fuels Inaction

Climate change denial by politicians in both Houston and Venice, and throughout the world, is one major conflict in passing legislation to combat the effects of climate change and rising sea levels. In the United States, there is a partisan split over global warming that has been polarized since the late 1990s. Two policy regimes have been competing for over a century. They are market liberalism, which favors capitalism, property rights and a minimal social safety net, and social liberalism, which favors modest state intervention, redistribution and welfare provision. Market liberalism is prominent in both political parties, with the Republican Party as its prime carrier (Antonio 195). Market liberalists do not often support climate change combative policy, and many politicians deny it because it is not in their interests. Rand Paul said of climate change legislation: “it’s anti-American and anti-freedom” (Antonio 195).

Climate change denial is prominent throughout the Republican Party. This leads to conflict in resolving issues in the United States, particularly Houston, which is located in a Republican-dominated state. In a recent Pew Research Center survey in 2010, only 16 percent of Republicans agree there is “solid evidence” of global warming and only 14 percent see it as a serious threat (Antonio 198). In both Houston and Galveston, climate legislation has still failed to pass. Despite the warnings signaled by Hurricane Katrina, Superstorm Sandy and other recent devastating storms, it might take another storm of that scale to hit Houston itself

before legislation can be passed to fight the rising sea levels at home in the Gulf of Mexico.

Many climate skeptics refuse to support climate change legislation because they see it as a threat to capitalism. To completely work to combat climate change, they believe a fundamentally new social system would be required and capitalism would not exist anymore. Capitalism focuses on production and competition between enterprises to expand their scales of production. Politicians who support capitalism fully, do not want to act to reduce fossil fuel consumption. Divestment from fossil fuels would harm the enterprises that produce fossil fuels and rely on their production to function. Divesting from fossil fuels would hinder the capitalist system that many market liberalists support (Li).

United States' interests are another major roadblock to success in combatting climate change related issues in Houston and across the nation. The two major sources of catastrophic risk in the United States are terrorism and climate change. While the United States has responded heavily to the threat of terrorism, they have done very little to address the risk of climate change in comparison. The cost of the Iraq War is in large excess of the projected cost of the Kyoto Protocol (Sunstein). The United States has chosen to spend more money and efforts addressing terrorism because it is in the interest of the government and a large number of American citizens. After 9/11, many Americans view terrorism as the highest risk to the safety of the public. Terrorism has a direct and immediate effect on the

American people. Climate change has not had direct effects on the lives of the public. So far climate change has only fueled heavier storms, droughts, flooding and seen slightly warmer temperatures. While many Americans can clearly see the costs of ignoring climate change future generations will face, they prefer the immediate benefits of spending that money on anti-terrorism initiatives (Sunstein 524-31).

4. ENVIRONMENTAL DESIGN

4A. A Dutch Model to Follow

The citizens of the Netherlands have battled rising sea level for two millennia, longer than any other nation. Throughout the years this rising sea has been incorporated as a part of life that cannot be changed, and the people have dealt with it accordingly. They know they cannot change the sea and that they must do what they need to for their survival. They have lived for centuries building dunes and dikes, both natural and human made. They are flexible with their constructions and make structures that can be adapted as time goes on and changes to sea level occur. While words like “levee” and “dike” are not common knowledge for students throughout the United States, one author says that this information is “the stuff of kindergarten classes” in the Netherlands (McHarg 7). For all of these reasons, their series of levees, storm surge barriers and other sea blockades is a successful model that Venice, Houston and New York City can look at as a model for their own policies. This system is called the Delta Works.

The Delta Works system was built in the Netherlands after the flooding disaster of 1953. It is a system of large dams that offers safety from flooding by providing protection levels much higher than those found in New Orleans. 25 percent of the country lies below average sea level, and without the system, 65 percent of the country has historically been susceptible to flooding from sea and rivers. The Netherlands consists of two deltas from the Rhine and Meuse Rivers, as

well as smaller Scheldt and Ems Rivers. There are many natural dunes that protect the land below sea level, as well as many man-made dikes, and now the Delta Works. Dutch politics allow for such constructions because the problem of flooding from the sea is centuries old and there is confidence in the engineers and management systems that design and carry out these projects.

In January 1953 there was a spring tide combined with a long northwesterly storm that set water levels high. The next morning the dikes that then existed in the Netherlands broke at over 900 locations. Over 2,000 square kilometers of land were flooded. 750,000 people were affected and 1,834 drowned. Once the extent of the disaster was realized, national politics moved very quickly to find a solution. The result of this storm was the Delta Works system. The implementation began before the government even carried out formal parliamentary approval of the construction plans.

The Netherlands has since constructed a system protecting a large region of the land surrounding the Rhine-Meuse-Scheldt delta from the surrounding sea. The Delta Works consists of dams, sluices, locks, dikes, levees and storm surge barriers. The dams, sluices and barriers all reduce the Dutch coastline so fewer dikes have to be raised when storms and flooding periods occur. In recent years, Dutch officials have advised Venice, Houston and New York City environmental policymakers, and aspects of the Delta Works system can be seen throughout all of the following cities' environmental design projects I have researched.

4B. Venice: Project MOSE

City officials have worked with the Italian government and the largest construction firms in the country to find a solution to stop Venice from flooding. One solution they agree upon is to line the bottom of the lagoon's three entrances with 79 hollow steel gates that could be raised to hold back the sea during acqua alta. The proposed project is referred to as Project MOSE ("Modulo Sperimentale Elettromeccanico" in Italian, or "Experimental Electromechanical Module" in English). When a storm occurs at high tide, compressed air would be pumped into the gates and force the water out to enable the gates to rise and form a barrier against the sea. The Italian government first announced the proposed project construction in 2001, with operation of the gates to begin between 2007 and 2010. However, the Venice City Council voted to reconsider construction in 2002. Critics of the project oppose the project, believing rising sea levels will make the Project MOSE gates obsolete within just a few years, and that raising the gates too often would harm aquatic organisms living in the lagoon (Pannone).

Project MOSE was eventually passed, but is still a controversial solution to the flooding problem in Venice. The project is currently under construction and the city's flood barrier system is scheduled for completion in 2014. Dutch engineers have given their advice and support of the system. NASA climatologist Vivien Gornitz says that sea levels are already rising faster than the Intergovernmental

Panel on Climate Change originally estimated, and if they rise more than 26-53 centimeters by the end of the century, MOSE would not be able to save the city. The projected MOSE will only be able to handle 60 centimeters of sea level rise before collapsing. Other alternatives have been proposed, such as pumping seawater into an aquifer below the lagoon to buoy the city by as much as 30 centimeters over a decade (Barley). Project MOSE still remains the government's prime solution at the present time.

4C. Houston: Ike Dike

The Ike Dike is the proposed solution to combat rising sea levels in the Houston area that I have already noted is having political issues with beginning construction. It is a defense system modeled after the Delta Works system in the Netherlands. It is a proposed 60-mile storm gate named after Hurricane Ike, the famous Category 2 storm that devastated the Houston metropolitan area in September 2008, killing more than 70 people and causing \$30 billion in damages (Fears).

Proposed by Texas A&M University professor, William Merrill, the Ike Dike has only recently begun to receive significant funding in the wake of Superstorm Sandy on the East Coast. This was 4 years after its initial proposal. While it still has not made enough money to become a reality, the project now appears to be more possible.

The proposed barrier would stretch across the mouth of Galveston Bay, attaching to Port Bolivar on one side and Galveston Island on the other side. It would be an extension of the currently existing Galveston sea wall. The Ike Dike would allow ships to pass into Houston through a gate. This gate would be closed when the waves rise during storms. When closed, the gates would block storm surges of up to 17 feet (Fears).

Dutch engineering experts have worked with officials in Galveston on the proposed Ike Dike project, just as they have assisted with the storm protection system in Venice. However citizens of the state of Texas lack the political will and understanding of the situation the Netherlands has seen for centuries. If the Ike Dike manages to find political and economic success, the system has the potential to be just as protectant as the Delta Works.

4D. Superstorm Sandy Wakeup Call

Superstorm Sandy showed New York City that changes to the urban design were necessary action to alleviate the potential problems caused by future storms similar to Sandy. In June 2013, the City released a comprehensive plan containing recommendations for rebuilding communities affected by Sandy and to increase the resilience of infrastructure and buildings throughout the entire city.

New York City's comprehensive coastal protection plan is called the SIRR, or Special Initiative for Rebuilding and Resilience. The plan covers a comprehensive

list of elements related to the city's infrastructure and built environment. These include, but are not limited to coastal protection, economic recovery, insurance, transportation, parks, healthcare and many more areas. As the coast is hit most directly by the storm, I believe it is important to protect it and do what is most helpful to combat the damaging storm surge in the first place, so I will focus on the City's plan to rebuild and make the coast more resilient.

One would think that a storm surge system barrier might work in the New York Harbor as it has in the Netherlands, but the City is approaching a different solution. The concept is attractive, but the City believes that relying on a solution of such a large scale would create huge risks for the city that outweigh the benefits. Because of this, the City is taking an approach using an integrated system of discrete coastal projects that work together to achieve coastal resilience (Bloomberg 50).

New York City justifies the advantages of its approach using three reasons. The first is that the city's chances of system failure will be lowered if there is a diversity of technologies to rely on. The example they give is New Orleans' failed levee and main defense system during Hurricane Katrina where the city was left completely unprotected. The second justification is that the system proposed will be scalable to available resources and will not require that all resources are necessary before moving forward with action in an emergency. And the third justification is that certain elements of the plan can be put into action immediately and we won't need to wait decades for the solution to reach completion (Bloomberg 50).

There are four main strategies involved in New York City's coastal protection program. They are to increase coastal edge elevations, minimize upland wave zones, protect against storm surge, and improve coastal design and governance.

The first strategy will be addressed in several ways. Sea level rise threatens to flood certain neighborhoods with daily or weekly tidal floods by the 2050s. That decade isn't so far from today. This risk will be addressed by increasing the height of vulnerable coastal edges. Bulkheads, structures made of stone or concrete at the water's edge, have been installed to hold shorelines in place and provide land for commerce near the city's rivers. They can also protect the coast from erosion. Raising these bulkheads can mitigate the effects of rising sea level in low-lying areas prone to flooding. Beach nourishment is also important because adding large quantities of sand can widen and elevate beaches after erosion caused by significant storms.

Minimizing upland wave zones is another goal of the SIRR. This is being accomplished by planting dunes, reinforced sand mounds along the back edge of a beach. They provide redundant coastal protection. The goal is to knock down waves and diminish their velocity before they reach and damage neighborhoods. It will reduce damage to buildings and infrastructure.

The third goal of the SIRR is to protect against storm surge. Storm surge is the most threatening element of rising sea level in New York City, and the City must work to keep the surge's water away from vulnerable neighborhoods and critical

infrastructure. This will be accomplished by using floodwalls, levees, and local storm surge barriers. They will allow for a 100-year sea level elevation plan with additional allowance to add for future sea level rise.

The final goal of the SIRR is to improve coastal design and governance. This will ensure the successful implementation of the first three strategies. By studying how open spaces and natural areas can be used, they can be revitalized and turned into waterfront areas that can benefit the quality of life in these affected neighborhoods. For example, there is currently work being done at Far Rockaway to redesign the neighborhood and make it more appealing to city residents in the warmer months by adding entertainment options. To promote the designs to the public, there was even a contest allowing entries with ideas to revitalize the waterfront. By making these neighborhoods more attractive, the City is developing neighborhood partnerships to allow permits for the coastal protection plans desired (Bloomberg 46-66).

CONCLUSION: WE MUST EDUCATE THE PUBLIC

Regardless of climate change, Venice has always been susceptible to high waters due to its location and Houston has always been susceptible to hurricanes due to its location. Both cities have foundations that are not naturally conducive to the existence of a large urban area. Venice has struggled with its foundation longer as it is an older city, and has seen an increase in the dangers of the rising water as a result of climate change. Houston has struggled for a shorter time than Venice, but has also undoubtedly seen increasing dangers of flooding from hurricane storm surges fueled by climate change. Venice has been more productive in passing environmental policy legislation to stop the flooding of the city, as it has seen the problem for many more years than Houston has and has had more time to evaluate proposed projects. Houston progress has been halted because of local politicians' climate change denial rooted in capitalistic interests, as well as lack of interest in climate change because it is not viewed as affecting the current generation. Though New York City has seen hurricanes before, they have not been to the extreme extent of the recent Irene and Sandy. Severe storms are not regular occurrence in New York City and climate change has driven them to become more frequent and stronger. I believe environmental policy is having an easier time passing in New York City due to stable government and an interest by the city's government.

The IPCC scientists' 2007 Assessment Report concluded that "most of the observed increase in globally averaged temperature since the mid-20th century is

very likely (90% probability) due to the observed increase in anthropogenic greenhouse gas concentration” (Pollack 151). This means there are 9 out of 10 chances that this is true. If I was in a casino and told my chances were 9 out of 10 that I would win if I played a game, I would surely take those chances. Yet even with probabilities this high, in 2008 only three out of five Americans polled believed climate change existed or that humans were responsible (Pollack 152).

I know there are many reasons for climate denial and skepticism. There are four main reasons why people continue to be skeptical. They are that the instrumental record of surface temperature change was flawed, the causes of climate change are completely natural, the consequences of climate change are beneficial, and that the economic cost of addressing climate change is not worth the effort (Pollack 108).

I believe denial and skepticism are huge roadblocks to finding successful policies to combat the rising sea level issues our cities face. My policy recommendation is to change the public opinion on these topics. This can be accomplished by establishing environmental education in schools. Many people aren't educated on climate change and see it as a very political topic affiliated with liberal politicians. Growing up in Texas, I had a high school science teacher tell me climate change wasn't real because Al Gore was a Democrat and a liar. Just because of An Inconvenient Truth, and this teacher's support of the Republican Party, she was forming an uneducated opinion. She told me she had never even seen the film,

and was spreading her opinion to young people in the form of teaching a high school science class.

There are surely many other Americans who were polled who don't believe in climate change that probably couldn't even tell you what IPCC stands for. The facts are not given in schools, so many people are just uneducated on the topic. Everyone learns algebra, the Civil War, grammar and mitosis, but climate science is not taught in schools on a nationwide level. Environmental education is lacking in our education system, and implementing programs in every school to annually educate our students would help spread the knowledge to young people. Things like Earth Week promote planting trees and turning off lights, but the bigger and more complicated issues are not touched on. I recommend that we instill more detailed environmental education to students during times like Earth Week. With programs such as this, we can change and educate the public opinion on climate change, and we can get our polls up to 9 out of 10 believe, the scientific probability of existence detailed.

Environmental politics are often problematic because of policymakers' and voters' reluctance to agree with climate change legislation, due to skepticism. Environmental design is a very common form of environmental legislation as it is a beneficial solution to combatting rising sea level. Using natural science data and environmental history in education systems worldwide, we can create a better understanding of how human behavior causes climate change and how the effects of

climate change come back to haunt humans. Once this understanding is established, real design solutions can be fully implemented for the benefit of all.

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