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New York City Underwater: Climate Change Mitigation and Adaptation

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New York City Underwater: Climate Change

Mitigation and Adaptation

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Submitted in completion of the Environmental Policy and Urban Studies Majors

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Abstract

I address the effects of climate change on New York City, and what can be done to minimize these effects. I explain the causes and impacts of sea level rise on New York City, specifically referencing New York City policies and programs that can help mitigate these impacts. I use data from New York City government, the New York City Panel on Climate Change, and the Intergovernmental Panel on Climate Change to collect information about greenhouse gas emissions, and describe how this leads to sea level rise. Then, I use environmental socio-economics, urban planning, and environmental politics in New York City as my social science disciplines. The quantitative climate change data and the three social science disciplines are integrated to help offer solutions for sea level rise. The data explores why greenhouse gas, especially carbon emissions, cause climate change and increasing global temperatures. I incorporate the environmental history of Hurricane Sandy and the topography of New York City to explain why lower class New Yorkers are more vulnerable to damages from sea level rise. I use aspects of urban planning to offer ways to reduce greenhouse gas emissions and promote energy efficiency in buildings. I use environmental politics to explain what New York City has planned regarding urban resiliency to better prepare for future severe storms and flooding. I conclude with policy recommendations including both mitigation and adaptation strategies for New York City, emphasizing that greenhouse gas mitigation is the most necessary to combat climate change.
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Introduction: Climate Change and New York City

Climate Change is a global phenomenon. Sea level rise is a consequence of climate change, and New York City is already experiencing the burden of it. New York City is home to millions of people, and is one of the top tourist destinations in the world. This coastal city experiences impacts from the changing climate every day, and needs to prepare for the future, to continue being a top global city and support its growing population. It is hard to notice the effects of climate change right away, because many changes are gradual. However, coastal cities notice changes easily because of greater vulnerability to flooding. When Hurricane Sandy hit in the fall of 2012, New York City was unprepared and astonished about the level of devastating destruction. Hurricane Sandy gave New Yorkers determination to combat climate change and live differently.

Below, the topic of climate change is explored, looking mainly at the impacts of sea level rise on New York City, and what New York City is doing to reduce the amplification of effects. Even before Hurricane Sandy, the New York City government has been planning goals to become more sustainable. “New York City is committed to reducing its greenhouse gas (GHG) emissions by 80 percent by 2050—the level the United Nations projects is needed to avoid the most dangerous impacts of climate change—and will chart a long-term course for a total transition away from fossil fuels to renewable sources of energy”\(^1\). Chapter 1 explains that greenhouse gas emissions are a main contributor to anthropogenic climate change, influencing global changes that have a wide range of effects. Chapter 2 explores the economic and health impacts associated with climate change and sea level rise, and what Hurricane Sandy did to thousands of New Yorkers. Chapter 3 looks at green

building as a method to reduce greenhouse gas emissions in New York City, and chapter 4 explains the importance of adaptation and resilience strategies to reduce the burden of climate change on New York City and its residents. Finally, chapter 5 explains policy recommendations to fully integrate greenhouse gas reduction goals and plans into New Yorker’s everyday lives. People need to be aware of the destruction caused by anthropogenic climate change, and be willing to change the way they go about their everyday lives to protect the Earth.

Chapter 1: The Science of Sea Level Rise

There are 7.2 billion people on Earth, and that number is growing at an incredibly fast rate. Climate change has a direct effect on the Earth’s natural and built environments as well as the growing population. One of the biggest threats to coastal cities in this era of climate change is sea level rise. Coastal cities, especially New York City, are already prone to flooding from storm surge, and with the current projections of sea level rise, the future does not look promising. Sea levels have already risen some 3.1 millimeters per year since 1993, and “projections for sea level rise in New York City show an increase between 11 inches and 21 inches by the 2050s”² Humans are largely responsible for climate change from burning fossil fuels and deforestation of rainforests. However in New York City, buildings are the main contributors to greenhouse gas emissions. If humans do not take action on global climate change, New York City and other populations will be in trouble. It is important to understand what causes climate change and why sea level rise is an issue. This chapter will explore the science of sea level rise and look at projections for the future.

Most importantly, sea level rise is caused by climate change. As the Earth’s climate warms up from anthropogenic causes, heat gets trapped in the atmosphere and in the oceans. As oceans heat up, they expand. Much of the noted sea level rise is caused simply by the oceanic thermal expansion. Also, warming global temperatures causes ice to melt. Glaciers, polar ice caps, snow, and permafrost are all examples of ice forms that are melting because of global warming. A changing climate can also severely impact the weather patterns around the world, increasing chances of stronger, more devastating storms. Sea level rise and stronger storms makes coastal, low lying areas more vulnerable to disasters because of their location. We have already seen this in New York City during Hurricane Sandy in October 2012. It is important to understand the science of climate change and how anthropogenic influences cause sea level rise.

First, there is a difference between climate and weather. Weather is the short-term description of the state of the atmosphere, whereas climate is the average daily weather over a long period of time. Wind, ocean and air currents, and localized temperatures and conditions affect weather patterns, and weather patterns can change daily. However, a warming climate can disrupt natural weather patterns, making storms more severe and impactful on coastal cities. Mixing severe storms with sea level rise can cause serious flooding damages and economic despair for coastal areas. “According to the World Meteorological Organization, the minimum period considered for purposes of measuring climate is three decades.”

Climate changes naturally. Solar patterns, global air circulations, and the concentrations of various gases in our atmosphere all naturally affect the climate.

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However, climate scientists have begun to see a correlation of changes in climate from increased human impacts, and this correlation has become more of an issue in the last 50 years. Changes in climate due to human activity are called anthropogenic climate change.

Climate Change is caused by changes in the composition of the Earth's atmosphere. The Greenhouse Effect is a natural process that “warms the earth's lower atmosphere and surface and thus affects the earth's climate. It occurs when some of the solar energy absorbed by the earth radiates into the atmosphere as infrared radiation [also known as heat]”\(^5\). The lower atmosphere is composed of greenhouse gases including water vapor, carbon dioxide, methane, and nitrous oxide. As infrared radiation interacts with the greenhouse gases, it increases their kinetic energy, which in turn warms the lower atmosphere and the earth's surface, and changes the climate. The human population is completely dependent on the natural greenhouse effect, because without it, earth would be too cold to be habitable. However, anthropogenic impacts have significantly increased the levels of greenhouse gases in the atmosphere, which has escalated the natural effect.

Anthropogenic climate change has a big impact on the Earth's climate system, which is compromised of the atmosphere, hydrosphere, lithosphere, biosphere and cryosphere. Of these different components, changes that affect the cryosphere, which is the Earth's frozen component including all ice, snow, glaciers, and frozen ground has the biggest impact on sea level rise. “Given that all of its components are inherently sensitive to temperature change over a wide range of time scales, the cryosphere is a natural integrator of climate

\(^5\) Miller, 495.
variability and provides some of the most visible signatures of climate change⁶. The melting cryosphere causes sea levels to rise, as more of this ice becomes water. Local sea level rise differs from the global average because of shifting surface winds, the expansion of warming ocean water, and the distribution of land ice, which affects the gravitational field of the Earth. In fact, sea level rise around the melting glaciers is usually less than around coastal areas, and the sea level is not globally uniform. Also, most of the increase of energy in the climate system, close to 80 percent, has been stored in the ocean, which causes ocean thermal expansion⁷.

The start of the Industrial Revolution in the mid-1700s marks the most significant increase in the burning of fossil fuels. Many climate scientists compare pre-industrial revolution data to post-industrial data because there is a strong correlation between increased human consumption of technology to increased greenhouse gas emissions. Technologies advanced to keep up with the demand for a growing economy, and fossil fuels were needed for new forms of transportation, agricultural practices and manufacturing. “The burning of fossil fuels tops the list of human activities that emit Carbon Dioxide, with coal being by far the highest emitter. The average atmospheric concentration of carbon dioxide rose from a level of 280 parts per million at the start of the Industrial Revolution to 389 parts per million in 2010”⁸. “CO2 emissions from fossil fuel combustion and industrial processes contributed about 78% to the total GHG emission increase between 1970 and

⁸ Miller, 497
2010, with a contribution of similar percentage over the 2000–2010 period”. Along with carbon dioxide emissions, methane emissions have significantly increased as well from industrialized agriculture techniques, creating landfills, and flooding land to create reservoirs.

Greenhouse gas emissions from human activities play a major role in global warming and climate change. If greenhouse gas concentrations continue to increase, the earth is likely to experience rapid atmospheric warming and climate disruption in this century. The warming climate from human activities causes ice caps to melt and disrupts the Earth’s natural glacial and interglacial periods. The warming climate is directly correlated to sea level rise from melting ice caps and sea ice, and has negative effects on coastal cities. “Climate change exposes people, societies, economic sectors and ecosystems to risk. Risk is the potential for consequences when something of value is at stake and the outcome is uncertain, recognizing the diversity of values”. In the case of sea level rise, coastal cities and developments are at risk because of the uncertainty of flooding and damage associated with higher sea levels. The risk and impacts associated with sea level rise on New York City is examined more closely in Chapter 2.

Sea level rise is a threat to our future, and humans bear a large responsibility for the warming climate. The cryosphere is the frozen part of Earth’s natural landscape. This includes glaciers, snow, permafrost, and sea ice. Lower atmospheric warming from the greenhouse effect immediately impacts the cryosphere because of its location near the

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Earth’s surface. Land surface warming leads to melting snow, glacial shrinkage, and permafrost degradation. Ocean surface warming and changes in surface ocean current patterns leads to sea ice recession. “In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality. Glaciers continue to shrink almost worldwide due to climate change, affecting runoff and water resources downstream. Climate change is causing permafrost warming and thawing in high latitude regions and in high-elevation regions”\(^{11}\). Altering hydrological systems because of climate change affects the melting of ice and thawing of permafrost, which impacts sea level.

The natural greenhouse effect is important to sustain human life on earth. However, the science behind and linkage between human greenhouse gas contributions and the warming atmosphere leads to unnatural effects which ultimately disrupts ecosystems and makes Earth’s natural climate more susceptible to changes. The burning of fossil fuels including coal, petroleum, and natural gas increases the amount of greenhouse gas, mainly carbon dioxide, into the atmosphere, which interacts with the infrared radiation from the sun. Polar ice cap melting is a consequence from the amplified warming of the Earth’s climate due to human impacts.

The Intergovernmental Panel on Climate Change (IPCC) is a network of more than 2,500 climate scientists from 250 countries who began documenting past climate changes in 1988 and use data to project future climate changes. The most recent assessment report was released in 2014, and the synthesis report integrates the findings from three working groups to the 5\(^{th}\) Assessment Report. Figure 1 below shows the total annual anthropogenic

GHG emissions by groups of gases from 1970 through 2010. In 2010, 49 Gigatons of carbon dioxide equivalent or 49 billion tons of greenhouse gases were emitted into the atmosphere, and has a 2.2% increase per year.

These high Greenhouse Gas contributions are likely to further shrink and thin the Arctic sea ice cover, decrease northern high latitude springtime snow cover and permafrost. If GHG emissions continue at this annual rate, it is projected that the Arctic Ocean will be nearly ice free by 2050, and the global sea level will rise.

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In New York City, Greenhouse Gas emissions in 2013 were 48.02 million metric tons of carbon dioxide equivalent\textsuperscript{14}. Despite this being a reduction from 2005 GHG emission levels, sea level rise from global climate change continues to be a major threat and increases the risks posed to communities and infrastructure. Sea levels in New York City are rising faster than the global rate, at an average of 1.2 inches per decade since 1900. This could be because of the unequal distribution of melting ice. “It is virtually certain that sea level rise alone will lead to an increased frequency and intensity of coastal flooding as the century progresses. Projected sea level changes alone would increase the frequency and intensity of coastal flooding”\textsuperscript{15}. Figure 2 shows sea level rise projections and what areas of land will be flooded if measures are not taken to reduce climate change and sea level rise. New York City has an estimated 1,850 miles of tidal shoreline that is densely populated and developed. Noticed in Figure 2, much of the low-lying area directly next to the water is threatened. Also, over 400,000 New Yorkers live in the city’s high-risk floodplain, and most of these people are in the working and middle class\textsuperscript{16}.

The science of Climate Change and Sea Level Rise is important to understand in order to reduce the anthropogenic effects of climate change. If efforts are not taken to reduce greenhouse gas emissions by living more sustainably, sea level rise will continue to increase and much of New York City will end up flooded or at a extremely high risk of becoming flooded.

Figure 2: Future 100 year flood zones

Chapter 2: The Socio-Economic Impacts of Sea Level Rise

Economic Impacts. Sea Level Rise poses a serious risk and threat to New York City, especially the low-lying areas and the communities and infrastructure that are there. “With 520 miles of coastline, New York City is extremely vulnerable to both catastrophic flooding and escalating insurance rates”\(^{18}\). Space is crucial in New York City, and as the trend towards living in cities only increases, it is important to recognize how sea level rise will have an economic impact on communities regarding affordable housing prices, flood insurance rates, and housing development. This economic burden will most likely have a larger effect on lower-class individuals and neighborhoods. Most of the time, lower socio-economic status families and neighborhoods are at the most risk from increasing sea levels and flooding due to climate change, because they do not have the resources to develop a fully integrated resilience plan, and they live in more flood prone areas. In the case of New York City, communities and government officials are able to look at the damage and devastation caused by Hurricane Sandy, to learn and plan for the future. Hurricane Sandy is a great example of a strong, devastating storm that had incredible storm surge, which caused destruction to communities, infrastructure and landscape. Rebuilding damaged neighborhoods caused a significant economic burden on New York City, and situations like this can easily repeat if sea levels and temperatures continue to rise.

Atmospheric warming increases the severity of weather events like hurricanes, droughts, and heat waves. Evidence is mounting that human-induced warming is increasing the frequency and severity of extreme weather events, because human impacts accelerate any natural warming process. As mentioned in chapter 1, there is a natural

greenhouse warming effect in the atmosphere that is essential for human life on earth. However, anthropogenic greenhouse gas emissions are amplifying and accelerating the natural process by increasing the amount of heat-trapping greenhouse gases into the atmosphere, increasing temperatures and causing oceanic thermal expansion. “In 2008, climatologists Mark Saunders and Adam Lea analyzed data collected since 1950 and found that for every temperature increase of 1 degree Fahrenheit in the water temperature in the Atlantic Ocean, the overall number of hurricanes and tropical storms increased by about a third, and the number of intense hurricanes... increased by 45%”19. This was proven in 2012 when Hurricane Sandy ripped up the East Coast, and what is worse is that storm surge reached higher land because of the progressive rise in sea level. “New York City’s low-lying areas are home to a large population, critical infrastructure, and iconic natural, economic and cultural resources. These areas are currently exposed to coastal flooding by warm-season tropical storms such as Hurricane Sandy and cold season nor’easters. Sea level rise increases the frequency and intensity of coastal flooding. For example, the ~12 inches of sea level rise in New York City since 1900 may have expanded Hurricane Sandy’s flood area by approximately 25 square miles, flooding the homes of more than 80,000 additional people in New York and New Jersey alone”20.

Hurricane Sandy gave New York City a big wake-up call into understanding the effects and severity of climate change. 17 percent of New York City was flooded, almost 90,000 buildings were damaged and 44 people were killed. What is worse is that most of the land flooded was lower income neighborhoods, where families have little savings or

credit, and restoring a home is very costly. "The rising tides caused by climate change, along with the rising costs of flood insurance, put the safety, housing affordability, and neighborhood stability of many of New York City's neighborhoods in and around the coast at grave risk". Threats from sea level rise go beyond simply flooding land to affecting housing and economic stability. The immediate burden of having to repair thousands of damaged homes and buildings and having to restore faith in communities was hard enough. Now for the future, people have to be prepared for higher flood insurance rates.

The average income of the people who live in high-risk flood zones is less than $100,000, which includes civil servants, teachers, social workers, transit operators, firefighters and police, and social workers. These people essentially keep New York City running. After Hurricane Sandy, which hit New York in the middle of a mortgage crisis, many of these people who own homes were faced with foreclosure and displacement. Directly after the storm, banks held a moratorium on mortgage payments in an effort to minimize foreclosures. However, this did not help because after the moratorium, people owed large sums of money they didn’t have, particularly since most of their savings went into home repairs. “After Sandy, foreclosures spiked in almost every outer-borough flood-prone neighborhood”.

The fact that many of the people affected by flood damages were lower income families intensifies this situation.

Given the reality of rising tides and sea levels, and the fact that New Yorkers have more people living in flood prone areas than any other city facing an increased flood risk, more people will be required to purchase flood insurance. “In recent years, the federal

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government has issued new flood maps for New York City that, if enacted as expected in 2016, will dramatically expand the number of people who must buy flood insurance.\textsuperscript{23}

Also, New York City has a number of historic, valuable buildings that are at increased risk for flooding, and protecting these buildings from flooding is expensive.

The history of the New York City waterfront and how it developed explains why lower and middle class families live where they do, and explains why New York City is at such risk for flooding. Flood prone areas in New York City are home to relatively low cost housing, because the cost of land is determined by geography and politics. Much of the waterfront is less expensive, because it is on the outskirts of centralized Manhattan. Because Manhattan is an island with an extremely expensive central business district, much of the working class has been pushed outward, and land has become relatively cheaper than inland Manhattan. Also, most of New York’s waterfront is industrial, and has been for many years. The production of goods, warehousing, and the distribution of goods was all done near the waterfront. Industrial processes are big contributors to pollution and greenhouse gases, so the wealthier population did not live near this, and land was cheaper. Also, after World War I, when cars became a major form of transportation, highway construction began. Highways were built on the waterfront, starting with the FDR and West Side Highway, and expanding into a series of connecting roads, creating over 400 miles of highway.\textsuperscript{24} Now, coastal neighborhoods suddenly had to deal with smog, noise, and high speeds of car transportation. The outside location from Manhattan, the industrial process


and highway construction on the waterfront decreased the value of land, making it an affordable place to live for lower and middle class New Yorkers.

**Health Impacts.** Not only can sea level rise and climate change impacts cause economic burdens for people, especially lower to middle class New Yorkers, but climate change also poses serious health risks. “These changing climate hazards increase the risks for the people, economy, and infrastructure of New York City. As was demonstrated by Hurricane Sandy, populations living in coastal and low-lying areas, the elderly and very young, and lower-income neighborhoods are highly vulnerable”\(^\text{25}\). The built environment, which is anything manipulated and built by humans, is essential for modern life and is what makes New York City so iconic. For example, South Street Seaport, a historic New York port bringing in many tourists annually, was completely flooded and damaged during Hurricane Sandy. It is at constant risk of flooding and devastating impacts from sea level rise.

However, New York received almost 10.4 million dollars from FEMA\(^\text{26}\) to restore it. Effects from climate change including increased temperatures, stronger storms, sun exposure, and increased sea levels all contribute to damaging buildings, roads, and parks. New Yorkers spend money to fix damages of the built environment from climate change, especially because it is easy to see the damage being done. Health risks are often not noticed right away, or thought about as New Yorkers go about their everyday lives. However, climate change causes health complications. Although increased temperatures, heat waves, and increased levels of pollution from living in New York City cause the most serious health effects, coastal storms and flooding pose their own threats. Not only is climate change

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\(^{26}\) Meier, Allison. “Three Years After Sandy, South Street Seaport Gets $10.4 Million from FEMA.” Hyperallergic RSS. August 14, 2015.
affecting the environment, but it is also contributing to heightened health risks and illnesses.

New York City experiences the urban heat island effect. This means that New York City is warmer than any surrounding rural areas because of the infrastructure and amount of people living there. Heat islands can affect communities by increasing energy demands resulting in increased greenhouse gas emissions and lower air quality, which can pose health risks to people. 

"Urban heat island effect’ refers to the occurrence of substantially higher temperatures (especially at night) within an urban area than in surrounding less-built-up areas. A recent study in New York City found that the city’s heat island effect can reach 8°F. The urban heat island may enhance the health risks of climate-related warming. The urban heat island effect makes impacts from climate change more severe. Health conditions resulting from heat can be increased tiredness, stress, and heat stroke.

Considering that New York City is already warmer than surrounding areas, climate change can amplify these warming temperatures, and expose people to more heat-related illnesses and risk factors. New York is a growing city that is already overcrowded. It is easy for health to decline in overcrowded areas, especially if there is more pollution contributing to the urban heat island effect and climate change. Air pollution and smog contribute to respiratory and heart problems. So, increased greenhouse gas emissions in cities from the built environment causes the urban heat island effect. Climate Change amplifies this effect, and makes New Yorkers even more susceptible to heat and air associated health risks.

Along with the urban heat island effect, which is amplified because of anthropogenic climate change, sea level rise poses health risks to people as well. Because there is a

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likelihood of stronger storms and increased sea levels, people need to be aware of the risks associated with this. Storms and flooding can affect health by exposure to contaminated drinking water, floodwaters, mold and damaged housing. It can also lead to mental health effects and stress from traumatic experiences including evacuation, population displacement and cleanup and recovery after storms. These examples were seen during Hurricane Sandy. Sandy ended up catching many New Yorkers off guard. People were warned about the storm, but did not take evacuation notices seriously until it was too late. High winds and extreme flooding left people with no power, damaged property, and no way to escape. Of the 44 New Yorkers who died during Hurricane Sandy, almost 80 percent was because of drowning due to the high storm surge. “Although these deaths represent the most obvious and tragic impact of Sandy, they do not account for the storm's full impact on excess mortality from accidental and natural causes, as well as other nonfatal health impacts, in impacted communities.”

The health and financial stability of New Yorkers is seriously threatened by increasing temperatures due to climate change and sea level rise, especially because New York City is already warmer than surrounding areas from the urban heat island effect. People that are more prone to flooding and health issues are lower and middle class New Yorkers, who were, as a result, hit the hardest by Hurricane Sandy. In order to decrease the risk of mental and physical illnesses associated with climate change, and decrease the likelihood of more impactful storms like Hurricane Sandy and flooding from sea level rise, measures need to be taken to reduce greenhouse gas emissions. Also, New York needs to

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become more resilient to the changing climate, and prepare for likely future damages associated with rising sea levels. Plans to become more resilient can reduce the number of people who need to purchase flood insurance, and can help protect the city from flooding damages, allowing people to become healthier and more financially stable.

**Chapter 3: Greenhouse Gas Mitigation: Green Building**

Greenhouse Gas mitigation is the process of reducing the total amount of greenhouse gas emission into the atmosphere. In an era of rising sea levels and a warming climate, people have to change the way they live, and cities have to become more sustainable and energy efficient in order to reduce anthropogenic climate change and reduce the threat of sea level rise. Many Americans are apathetic to the changes happening in the environment and do not realize the serious threats posed by anthropogenic climate change. People do not understand how serious anthropogenic greenhouse gas emissions are because many results are gradual. For example, since 1900, sea levels in New York City have risen about 1.2 inches per decade. People might think of this as a very gradual increase because it is a little amount over a long period of time. However, our way of life requires the consumption of an enormous amount of resources, which leads to greenhouse gas emissions. We need to change our way of life and live more sustainably to reduce the drastic impacts on the environment. Hurricane Sandy proved that stronger storms and an increased sea level caused extensive damage to the built environment, economic resources, and the health of New Yorkers. New York has a growing population and a considerable amount of low-lying floodplain areas that will be damaged if sea levels continue to rise at the rate of 1.2 inches per decade. Hurricane Sandy caused people to experience an intense storm and realize that changes need to happen in order to protect the future of New York
City and around the world to reduce the possibilities of flooding, damaging storm surge, and economic burdens. Greenhouse gas mitigation is the most important strategy for people to learn and live by because if everyone starts reducing their carbon footprint, and if cities take action by implementing policies and initiatives to reduce greenhouse gas emissions, impacts from anthropogenic climate change will decrease. New York City has already begun making major improvements in their greenhouse gas emissions, but the infrastructure required to support an increasing population and the amount of resources it takes to sustain this infrastructure makes reducing greenhouse gas emissions difficult. That is why green building is one of the best ways to reduce greenhouse gas emissions in New York City, and allow people to live a more sustainable lifestyle.

The most integral aspect of New York City is the buildings that people live in and work in. New York City would not be a place of high demand without its buildings. Even though buildings are essential for modern life and contribute to peoples’ success, they also emit a great amount of pollution and have a negative impact on the environment. Buildings require extreme amounts of infrastructure and resources to build and sustain, which contributes to air, water, noise, and light pollution. Buildings also require energy and electricity to function, which can be very polluting, depending on what kind of resources the building uses. Buildings cause negative impacts to the environment and people, but with policies, initiatives and regulations, pollution can be reduced and buildings can become more sustainable, providing a healthier and safer environment for the people living in cities.

The building stock in New York City uses many resources and contributes the most to greenhouse gas emissions. “Roughly 75 percent of New York City’s greenhouse gas
emissions come from the energy used in our buildings—almost twice the national average. Moreover, it is estimated that more than 85 percent of New York City’s buildings will still exist in 2030. As a result, New York City has focused on improving energy efficiency in existing buildings and reducing the use of heavy heating oils”\(^{30}\). With the majority of greenhouse gas emissions in New York City coming from buildings, making them more efficient and reducing their GHG impacts is very important. Currently, New York City has several initiatives focusing on increased energy efficiency in buildings to reduce GHG emissions, and solutions like green roofs can also be a significant help in reduction, providing environmental and economic benefits to New Yorkers.

Not only do greenhouse gas emissions from buildings contribute to anthropogenic climate change, but they also contribute to air pollution, which impacts the health of people too. The type of heating oil used in NYC is slowly being phased out to more renewable, less polluting resources. Smog is a combination of greenhouse gases including sulfur dioxide, carbon dioxide, and soot. Also known as black carbon, it is the second most prominent greenhouse gas in the atmosphere, and the one that causes the most health issues. Smog and soot particles usually hang lower in the atmosphere, leading to larger amounts of respiratory health issues and asthma cases. Smog is considered the worst kind of air pollution contributing to both climate change and health impacts. Residual oil number 6 is extremely cheap, so popular by demand, but it also contributes the most to air pollution and greenhouse gas emissions, causing many health risks and accelerated climate change impacts. “Just 1 percent of all buildings in the city produce 86 percent of the total soot pollution from buildings—more than all the cars and trucks in New York City combined.”

\(^{30}\) New York City Mayor’s Office of Long-Term Planning and Sustainability. "PlaNYC 2030: Greener, Greater Buildings Plan." PlaNYC. October 2014.
They do this by burning the dirtiest grades of heating fuel available, known as residual oil, or #6 and #4 heating oil. Because of the amount of pollution produced from a small portion of NYC’s building stock, and given the number of buildings in NYC, the government has begun to take action to reduce greenhouse gas emissions. In 2007, PlaNYC was released, and a big goal in this plan was to improve the efficiency of buildings and reduce greenhouse gas emissions. In 2011, Mayor Bloomberg finalized a plan to phase out the highly polluting heating oil numbers 4 and 6 and switch to less polluting forms of energy, either natural gas or renewable resources like solar panels, wind energy biodiesel, or steam. This will reduce the amount of smog and soot produced, and significantly reduce sulfur dioxide in the atmosphere, a prominent greenhouse gas. For instance, natural gas, although still a fossil fuel, reduces Carbon Dioxide emissions 30 percent compared to Number 6 fuel heating oil. Making the change to cleaner heating options can significantly reduce harmful air pollutants in the atmosphere, making for a cleaner environment as well as healthier people and living conditions. Burning cleaner heating oil is also less expensive in the long run, because cleaner burners have a higher efficiency burn rate, and waste less heat. As New York City continues to phase out the usage of Number 6 fuel heating oil, the

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32 NYC.gov. "GBEE - Greening the City’s Codes & Regulations - Heating Oil Regulations." GBEE - Greening the City’s Codes & Regulations - Heating Oil Regulations.
Along with phasing out highly polluting residual heating oils from buildings, the New York City government has begun to take action to reduce greenhouse gas emissions regarding energy efficiency. “Since 2005, GHG emissions from buildings have declined 20 percent... as a result of the more efficient use of energy in City buildings”\(^\text{34}\). Much of this reduction is due to Local Law 84, New York City’s Greener, Greater, Buildings Plan. Because buildings are a top contributor to greenhouse gas emissions, this plan has set goals to target and provide an overall reduction in emissions. The buildings plan, GGBP, targets large, existing buildings greater than 50,000 square feet. These buildings are required to

\(^{33}\) Figure 3: City of New York, Inventory of New York City Greenhouse Gas Emissions, November 2014, by Cathy Pasion, Mikael Amar and Michael Delaney. Mayor’s Office of Long-Term Planning and Sustainability, New York, 2014, 12.

perform annual energy and water use benchmarking, and undergo energy audits every 10 years. The New York City government can set the example of increasing energy efficiency in public buildings like schools and government buildings to show private sector building owners the importance and benefit of increasing energy efficiency. As soon as the private sector sees changes happening, including both environmental and economic incentives, they will want to become more energy efficient as well. Buildings can become energy efficient by insulating windows, roofs, and walls, using efficient heating and cooling systems, and using renewable sources of energy. Many private building owners lack the information and awareness of the benefits of energy efficiency and don't see the financial incentives for retrofits. As a result of this lack of understanding, the opportunity costs for energy retrofitting projects are high. Although it initially costs money to invest in efficient retrofits, in the long run it will be very beneficial, from an economic and environmental perspective. Energy “efficiency improvements are expected to generate $1.4 billion in annual cost savings for New Yorkers, which can lower housing costs for tenants... and be reinvested in other building upgrades”.  

Making buildings energy efficient will not only reduce greenhouse gas emissions and reduce the risk of impacts from sea level rise, but it will provide an economic incentive to go green. New Yorkers and private building owners who retrofit their apartments or homes will save money in the long run.

In April 2015, Mayor Bill de Blasio released OneNYC, the plan for a strong and just New York City. The major sustainability goal is to reduce greenhouse gas emissions 80 percent of 2005 emissions of 59.11 million metric tons Carbon Dioxide equivalent to 11.82 million metric tons CO2e by 2050. The majority of this goal will be accomplished by making

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building energy efficient, because buildings emit the largest portion of greenhouse gas emissions in New York City. Luckily, there is already a plan for this, which is outlined in One City: Built to Last, released in 2014. It set the goal to reduce greenhouse gas emissions from buildings 30 percent by 2025. This is a new goal after Mayor Michael Bloomberg released PlaNYC in 2007. In PlaNYC, the goal was to reduce GHG emissions 30 percent of 2005 emissions by 2030. However, by 2013, NYC was already so close to the 2030 projection, which proved that the Mayor underestimated NYC’s reduction efforts.

The new goal set forth in OneNYC requires more citywide efforts and more sustainable building, but can be done, based on the success of PlaNYC’s goal. Increased energy efficiency by green building initiatives will have impressive results, but requires work. “To reach 80 x 50 the City must reduce 43 million metric tons of greenhouse gas emissions... 25 million metric tons [coming] from energy used in buildings”\(^{36}\). Along with switching from residual oil number 6 to cleaner heating alternatives, LEED certification, solar panels, and green roofs are examples of green building that can help achieve the goal of an 80 percent reduction of greenhouse gas emissions.

Buildings can reduce greenhouse gas emissions through Leadership in Energy and Environmental Design, or LEED certification, established by the U.S. Green Building Council. LEED certification provides a rating system unique to each building and project type, and for new buildings the building design and construction earns a certain amount of points. “The number of points a project earns determines the level of LEED certification certified, silver, gold or platinum”\(^{37}\). To ensure long-term sustainability, green building


designers work to reduce the burden of maintenance, include more windows for natural light and ventilation, and incorporate energy saving ideas such as efficient appliances into their buildings. New York City has many buildings achieving LEED standards, and is “setting the stage for the passage of LEED law, Local Law 86, which requires most new City government building projects and renovations to achieve LEED certification”\(^{38}\). This helps achieve the greenhouse gas emission goals set forth in OneNYC, by making the buildings more energy efficient and sustainable.

A great example proving the benefits on LEED certification is the Durst Organization, which is a real estate company in New York City. They are leading the way in sustainable development, management, and construction. “The company owns and manages more than 13 million square feet of Class A Manhattan office space, as well as 2 million square feet of residential rentals, including four luxury high-rise buildings”\(^{39}\). The Durst Organization has assembled One World Trade Center, the largest building in the nation designed to achieve LEED Gold certification, as well as One Bryant Park, the first LEED Platinum skyscraper. LEED standards are transforming the way buildings and communities are designed, constructed and maintained to provide healthier, less polluting cities. New York City can take steps to reduce greenhouse gas emissions from buildings by reducing pollution from heating and other everyday energy uses.

As buildings phase out polluting energy sources, renewable energy is an efficient source that does not emit greenhouse gases. Although natural gas is a cleaner, less harmful energy source, it still emits greenhouse gases because it is a fossil fuel that needs to be

\(^{38}\) The City of New York. "Energy and Buildings." PlaNYC.

processed. Solar energy is one of the best resources for efficient energy, especially in New York City that has many tall buildings with great sun access. “Solar photovoltaic (PV) energy has shown strong growth in New York City since 2007, from 1 Megawatt to nearly 20 MW in mid-2013”\textsuperscript{40}. Since 2006, the NYC Solar Partnership, led by CUNY has had a major influence on the installation of solar panels. NYC funds them to reduce market barriers for investing in solar power, and increase access and distribution of solar power to people with financial hardships and technical constraints. Lower and middle class New Yorkers living in low-lying areas of NYC will benefit the most from reducing greenhouse gas emissions and increasing energy efficiency, because they are the ones who will be most severely impacted by sea level rise. Solar Panels are becoming more common in green building, because along with being a totally clean energy source with no greenhouse gas emissions, they provide economic benefits for residents. Increasing NYC’s solar panel use also creates jobs for people, which boosts the economy. “Over ten years, the NYC Solar Partnership will help the City achieve its goal to install 250 MW of solar power across an estimated 30 million square feet of roof space in the city. By 2025, the installed capacity is expected to reduce annual GHG emissions by more than 105,000 metric tons of carbon dioxide equivalent, generate $70 million in annual energy cost savings, and create 460 construction-related and solar industry jobs”\textsuperscript{41}. Installing and using solar power reduces greenhouse gas emissions by lessening the reliance of burning fossil fuels for energy. It also boosts the economy by creating jobs, and creates more spending money as a result of less expensive electricity bills.

\textsuperscript{40} The City of New York. "Energy and Buildings." PlaNYC.
\textsuperscript{41} USA. The City of New York. Mayor’s Office of Long-Term Planning and Sustainability. One City Built to Last. By Bill De Blasio and Anthony Shorris. 2014, 74.
New York City is also implementing the use of green roofs. Green roofs, also known as living roofs, are roofs of buildings partially or fully covered with vegetation. Green roofs provide numerous environmental and economic benefits. First, they help mitigate the urban heat island effect by cooling the surrounding air and conserve energy by providing insulation in the winter and shading upper floors in the summer. This also reduces energy costs in the long run, offering similar incentives for building owners to implement as solar panels. Additionally, green roofs help improve air and water quality, because the plants on the roofs can capture airborne pollutants, which reduces the amount of carbon dioxide being released into the air. Green roofs reduce smog in the atmosphere, and increase the health of New Yorkers. They also capture excess water from rain, and can lessen the severity of floods by reducing storm sewers from overflowing into rivers. Also, green roofs are an excellent way to increase positivity and provide a place to relax from the stress and noise of living in New York City. Additionally, there are tax incentives to install green roofs on buildings. “New York City offers property tax abatements to property owners that install green roofs on their buildings”\(^{42}\). There are many benefits of green roofs that can help reduce the emission of pollution into the environment and improve the energy savings for New Yorkers.

Greenhouse gas mitigation by green building in NYC is the best option to reduce the potential risks and impacts of future damages in light of climate change and rising sea levels. Since buildings make up such a significant amount of New York City, reducing their emissions will yield the fastest, most meaningful results, improving the environmental quality of New York City and reducing its contribution to climate change. Reducing air

\(^{42}\) The City of New York. "Energy and Buildings." PlaNYC.
pollutants from switching to cleaner heating methods, and becoming energy efficient by LEED certification, using renewable energy, and installing green roofs can help achieve the goal set by Mayor Bill de Blasio in OneNYC to reduce greenhouse gas emissions 80 percent by 2050. Reducing emissions not only will reduce the rate of sea level rise, but it will also make New Yorkers more financially stable. Investing in green building retrofits saves money by making buildings more efficient by insulation, which reduces the amount of energy used. Also, using solar power is essentially free, because it comes directly from the sun, and does not require combustion to be used.

**Chapter 4: Resiliency and Adapting for the Future**

Although greenhouse gas mitigation is essential to address the problems and directly reduces the amount of stress associated with climate change, adaptation and resilience strategies are also important to cope with climate change and be prepared for its effects. Resilience is different from mitigation, as it is the process of adapting and making New York City stronger and resistant to impacts from the warming climate. It also involves rebuilding and putting a city back together after a tragedy. Change is inevitable. Environmental and social change will occur, and society needs to prepare for these changes. Adapting allows New York City to “anticipate and prepare for pressures and risks that climate change will introduce or worsen, and strengthen connections among individuals and networks”. Resilience is about coping with the changing conditions as a result of climate change, because even with greenhouse gas mitigation, New York City still has to be prepared for the future. Communities need to work together, buildings need to be protected, and plans need to be implemented to respond quickly and efficiently in the event

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of sea level rise. Hurricane Sandy sparked a change in the New York City government. All of
a sudden, federal and state funds were available to enhance the city’s resiliency. New York
City has a $20 billion climate resiliency program to help prepare for the worst threats of
climate change.\footnote{The City of New York. \textit{One New York the Plan for a Strong and Just City}. New York, NY: City of New York, Mayor’s Office of Long-Term Planning and Sustainability, 2015, 218.}

As mentioned in Chapter 2, the lower and middle class individuals are the most
affected by impacts from climate change. As the wealthier New Yorkers are able to shield
themselves from changes and harm, the disadvantaged population faces greater risks. The
gap between the rich and poor grows bigger. Resilience deals with bridging the social gap
in New York, and preparing all New Yorkers for the unknown future.

The advantages of switching to an energy efficient lifestyle prove that the gap can be
reduced, but it is also important to protect the communities in New York that are the most
vulnerable. “In New York City, Superstorm Sandy sparked a vibrant public conversation
about how to build a more resilient city—by modifying the built environment, restoring
began enacting many community action plans to be prepared for more extreme storms.
Resiliency is a key goal for New York City mentioned in Mayor de Blasio’s OneNYC. The
major goals addressed in OneNYC are to “eliminate disaster-related long-term
displacement more than one year of New Yorkers from homes by 2050, reduce the Social
Vulnerability Index for neighborhoods across the city, and reduce [the] average annual
economic losses resulting from climate-related events"46. New York City can achieve these goals and reinforce neighborhoods by strengthening community, social and economic resiliency, and upgrading buildings against climate change impacts, which can be done by increasing a building’s energy efficiency. Also, New York plans to strengthen its infrastructure systems including storm sewers and pipes to be able to withstand flooding, and establish stronger coastal defense mechanisms to protect against rising sea levels. In order for goals like this to be achieved, different government agencies and organizations have to work together with the citizens of New York. Building resiliency requires efforts from the whole city.

Urban Resiliency comes together with an emphasis on green infrastructure and disaster risk. As mentioned in chapter 3, green building reduces greenhouse gas emissions in an effective manner. The Kresge Foundation and the Island Press conducted a project dealing with Urban Resilience and released a report called *Bounce Forward: Urban Resilience in an Era of Climate Change*, that has important information about what coastal cities should do to prepare for sea level rise and future storms like Sandy. This information directly relates to New York City. They define urban resilience as, “the capacity of a community to anticipate, plan for, and mitigate the dangers—and seize the opportunities—associated with environmental and social change”47. Hurricane Sandy provided the opportunity for New York to strengthen its disaster risk plan, and build resilience to reduce their disaster risk and vulnerability. Although the government can enact plans and policies, the most important initiative dealing with resiliency and adapting for the future is

community involvement. An initiative that is planned within a community will build social capital, a key to building resilience and decreasing vulnerability.

OneNYC’s resilience goal to increase coastal defense was managed in a way to build social capital as well, through community involvement. One example of coastal defense is to build barriers or levees for protection against storm surge and rising sea levels, and is shown with the East Side Coastal Resiliency Project. “Hurricane Sandy vividly demonstrated the City’s vulnerability to coastal storms. With 520 miles of coastline, New York City has been exposed to these risks since its founding. Over the past 400 years, the City’s shoreline has been developed and modified in ways that have contributed to increased risks from coastal storms. Now, a changing climate is adding to the risks”48. The neighborhood between East 14th and East 23rd streets in Manhattan is a low-lying area, directly vulnerable to flooding. In March 2015, they started holding community design workshops to involve the community in the rebuilding and planning of the area to increase resiliency. New York City’s Housing and Urban Development branch provided funding for this project, under their Rebuild By Design competition, where resiliency plans were selected and implemented. Under New York City’s Coastal Protection Initiative 21, a flood protection system is to be installed on the Lower East Side. They decided to build a natural land barrier or levee to increase protection from storm surge and flooding. However, since this barrier is only going to serve a purpose in the event of a storm or severe flooding, it will be a community park at all other times. This levee or berm is a raised landform created to protect low-lying areas, like the Lower East Side of Manhattan, that can also be landscaped with grass, plants, and can become a public park with bike paths and green

areas. This is a great sustainable planning idea that builds resiliency and aids in combating impacts from climate change. Figure 4 shows where this levee and park would be.

![Figure 4: East Side Coastal Resiliency Project](image)

The idea is to turn this resiliency infrastructure into infrastructure for the community. Instead of walling off the neighborhood, this plan will increase protection from flooding, as well as give people the opportunity to waterfront access and enjoyment. "When in place, the ESCR Project will provide improved coastal protection to more than 110,000 vulnerable New Yorkers through 2.2 miles of enhanced waterfront, ecology, and urban spaces"[^50]. It will also strengthen social resiliency, because it will establish public space and waterfront accessibility. This project is expected to begin in late 2017, and will take


[^50]: Mayor's Office of Recovery and Resiliency. "PlaNYC 2030." PlaNYC.
approximately five years to complete. Although this is a long time, the planning associated with it requires research and involvement. It is a big step forward towards a better future for the Lower East Side of Manhattan. The New York City government agencies have been working together to achieve a more resilient city. The East Side Coastal Resiliency Project is a great example of what can be accomplished with the proper funding from the government and community organization and planning. Coastal Defense is a major goal for New York City resiliency, because of the 520 miles of coastline that will be affected by sea level rise.

Other resiliency plans include strengthening vulnerable neighborhoods. Land use policy can be useful to look at, especially after Hurricane Sandy. Low lying neighborhoods that were flooded and damaged can reduce flood risk. “Ten neighborhoods impacted by Sandy across the city are currently involved in planning studies to generate resiliency recommendations and land use changes, on both a local and citywide level. These recommendations are expected to reduce long-term vulnerability by smartly managing growth and development in [these] parts of the city”.51 Strengthening neighborhoods in relation to disaster preparedness also means having effective communication between government and communities. Access to emergency shelters, on-call emergency response, and recovery programs need to be secure. “Official resources are vital for community preparedness. One of the most critical components to disaster preparedness and response is effective communication between government and community stakeholders. This means

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the City must continue to work with local organizations before disasters strike”52. For example, the New York City Housing Authority and small business unions have been working together to form apprenticeship programs that will give many Sandy-impacted residents access to more jobs. With State funding, and appropriate programs, building stronger neighborhoods is possible. New York City government understands the importance of having rational and effective emergency plans and proper communication between the government and local business and resident stakeholders. When the government and community work together, the city becomes stronger and more prepared.

Another example of building resiliency and protecting New York City’s neighborhoods is by mitigating the risks of heat. Outlined in chapter 2, the urban heat island effect is a big problem that impacts lower income neighborhoods the most. The risk of dying from heat related illnesses is greater in neighborhoods with limited access to air conditioning. New York City is partnering with the Nature Conservancy to develop strategies to adapt to the impacts of urban heat, and identify the best science techniques to mitigate urban heat. Also, during extreme heat waves, the State will ensure low income and most vulnerable populations will receive air conditioning installation through the Federal Low Income Home Energy Assistance Program53. One of the key aspects to making New York City more resilient against climate related changes and consequences is by preparing the more vulnerable neighborhoods. Since the New York City government is partnering with many larger organizations, they are able to get the proper funding and support they

need to make relevant changes to living in New York City. Working together and building relationships makes communities stronger.

Enforcing New York City's building stock is important to build resiliency and withstand climate change impacts, especially because many of the buildings are aging and need repair. New buildings are constructed and designed to meet current codes that promote safety and energy efficiency. However, most of New York City’s building stock was constructed before these standards were in place, and therefore are usually ‘grandfathered’ into the modern codes. This includes single and multi-family buildings, public housing, and city-owned buildings. "There is a significant need to adapt buildings across the five boroughs to withstand and recover from extreme weather events and other hazards, while continuing to serve residents and businesses during normal conditions”54. The Mayor’s office plans to fund and adopt polices to support building upgrades. After Hurricane Sandy, investments were seen in homes throughout the city though the Build it Back program, which allowed residents and homeowners to renovate, rebuild, or sell their homes. Putting homes on stilts, raising the ground level, and flood-proofing lower levels are all examples of ways houses can gain protection from flooding. The Build it Back program was a very successful program, but it is also important to continue upgrading houses and other buildings, regardless if they were affected by Hurricane Sandy or not. With the future projections of sea level rise being something that needs to be kept in mind, repairs and upgrades to build more resilient buildings is necessary. This brings up another point, which explains the urgent need to update FEMA flood insurance maps.

Another way to enforce New York’s building stock is by updating FEMA flood insurance maps. The Federal Emergency Management Agency, FEMA, releases flood insurance rate maps for many coastal cities. The first map for New York City was released in 1983, and defined the 100-year flood plain as the area that has more than a one percent chance of flooding for any given year. This provided an expanse including approximately 35,500 buildings. “However, Sandy’s extensive flooding encompassed over 88,700 buildings, and according to current FEMA updates to these maps, the new 100-year floodplain is expected to include approximately 71,500 buildings”55. This will increase the number of people required to purchase flood insurance, and therefore it is critical to implement the new zoning codes into existing buildings. FEMA provided over $3 billion to the NYC Housing Authority to build resilience in 33 public housing developments, including elevating building systems such as electrical units, flood-proofing lower levels, and upgrading infrastructure56. Updating flood insurance rate maps is extremely relevant, and crucial because it allows more people to understand the high impacts of flooding and where flood zones are. Knowing this information could allow neighborhoods in high impact zones to better prepare for storms like Hurricane Sandy, and can allow them to become more resilient.

Not only does New York City benefit from this resiliency plan by becoming better prepared for climate change impacts, but it also provides people with job opportunities. Investments in resilience initiatives open the door for people who might have lost their job or home because of Hurricane Sandy. Improving infrastructure, enforcing the building

stock, and holding community meetings and planning creates job opportunities that will boost the economy, and also help New York City reach their resiliency goals. Providing jobs for people allows social resiliency to grow stronger, which is just as important as physical resiliency.

New York City has made so much progress moving forward from the damage and destruction caused by Hurricane Sandy. Resilience initiatives are vital for any city that wants to improve and bring communities together. In an era of climate change and sea level rise, New York City has to be prepared for the worst possible scenario. New York City is facing a serious threat of flooding, and adapting to these changes is crucial. This involves updating flood insurance rate maps, building levees to protect against flooding, and designing community projects and plans to build social resiliency. Hurricane Sandy allowed for many changes to occur, and acted as a wake up call to the potential and seriousness of future damages from sea level rise.

**Chapter 5: Conclusion: Combating NYC Climate Change**

In October 2012, Hurricane Sandy ripped through New York City and other East Coastal cities. Neighborhoods, homes, businesses, and infrastructure were severely damaged and people were distraught. Sandy caught many off guard, but it also raised awareness to the effects of sea level rise on New York City, and the damages strong storms can have on the City. Hurricane Sandy claimed the lives of 44 New Yorkers and caused $19 billion in damages and loss of economic activity. As New York City began its recovery efforts, it became apparent that recovery needed to prepare NYC for a wider range of risks, not just strong storms. Recovery needs to include plans and efforts to reduce the effects of climate change and prepare NYC for the worst. In the event of sea level rise from climate
change, and warming temperatures contributing to stronger storms, it is inevitable to reduce anthropogenic greenhouse gas emissions and aim to become a stronger, more resilient city. The Intergovernmental Panel on Climate Change set projections of sea level rise, and it is not looking promising for New York City or any other coastal city, unless changes are made. “According to the middle range of these projections, sea levels are expected to rise 11 inches to 21 inches by the 2050s, and 22 to 50 inches by 2100. Using the highest estimate of current projections, sea levels could rise as much as six feet by 2100. With this projected rise in sea level, the city's floodplain will continue to expand, creating more frequent and intense flooding, and underscoring the city's growing vulnerability to the many impacts of climate change”57.

Human beings are the cause of the increase in greenhouse gas emissions in the atmosphere. Although there is a natural greenhouse effect in the atmosphere, and it is necessary to sustain our lives, the capability and necessities of humans has caused excess greenhouse gas to enter the atmosphere. Ever since the Industrial Age, which amounted to more fossil fuels burned, and an increase in polluting technologies such as transportation, and clothing production factories, the atmosphere and ocean has been warming. A changing and warming climate can cause extreme changes to the weather patterns around the world leading to stronger storms, droughts, and other disruptions. Also, a warmer ocean and atmosphere leads to melting glaciers and ice, contributing to sea level rise. Anthropogenic climate change can be combated by sustainability initiatives and efforts to reduce carbon emissions.

Sea level rise is a big issue for New York City. As outlined in Chapter 1, sea level rise comes primarily from melting ice caps and thermal expansion from warming ocean temperatures. It is important to implement greenhouse gas mitigation and resilience strategies to protect New York City and other coastal areas from the threats of sea level rise. Reducing anthropogenic greenhouse gas emissions is the absolute best, and effective method to reduce the impacts of climate change and protect coastal cities and residents. Problems will not be fixed unless resolved from the root of the issue, and in this case, anthropogenic greenhouse gas emissions is the root of sea level rise and threats to New York City. Reducing greenhouse gas emissions can reduce vulnerability and risk for the future of New York City.

Adaptation to a changing climate is necessary, and New York City has plans to become more resilient and prepared for the unexpected storm and sea level rise. It is crucial that NYC is including community planning in their resiliency goals because doing this strengthens social resiliency as well. Reducing carbon and other greenhouse gas emissions will help lessen the impacts of climate change, and cities like New York will be more sustainable and safer from sea level rise, as well as better prepared for future risks.

Chapter 2 mentioned how lower class New Yorkers are the most vulnerable to climate change impacts, especially because the majority of them live in low-lying areas. New York City does a great job of addressing the needs of all its residents, however living more sustainably and upgrading to energy efficient appliances in homes provides an economic incentive and benefits the environment. New York City should create a policy that informs more residents of the economic benefits to energy efficiency, either through community involvement or information from electricity providers. It is important for New
Yorkers to be saving as much money as they can, especially lower class New Yorkers who are the most vulnerable, because it helps boost the economy and aids in reducing anthropogenic greenhouse gas emissions.

Also mentioned in chapter 2, lower class New Yorkers are more susceptible to heat related health issues, and switching to energy efficient appliances and increasing energy efficiency can help with this too. Reducing the amount of greenhouse gas emissions that contribute to the urban heat island effect will lessen the severity of heat related illnesses. New York City has many greenhouse gas reduction plans, but it is important to make the connection between health and illness and climate change. People tend to care about themselves individually. This involves their money and their health. Broadening the knowledge and communication with residents that living sustainably and efficiently can reduce health issues and save money, is a great idea and can help New York City reach its emission reduction goals. Also, tax reduction incentives for installing energy efficient appliances allows people to save money, which people respond to, and if this gets them to install an energy efficient appliance, they will see the benefits in the long run, financially and environmentally.

Fortunately, New York City has already taken steps to reduce its greenhouse gas emissions and carbon footprint. As mentioned in chapter 3, New York City government publications like PlaNYC and OneNYC have given New York a goal to reduce greenhouse gas emissions 80% by 2050. With efforts from the Office of Long-Term Planning and Sustainability, and other New York City agencies, this is a very attainable goal, mainly through greening the existing NYC building stock. Sustainable urban planning and greening buildings, which contribute the most to the greenhouse gas emissions in New York City, is
extremely important. It is vital for the New York City government to educate building owners about the importance and benefits of energy efficiency either with renewable energy sources or green roofs. Not only will this help reduce greenhouse gas emissions, but it is also an economic incentive for people, and will allow people to save money in the long run.

As mentioned in chapter 4, community involvement and planning is key in being successful in any new plan or goal set by the New York City government to become more resilient and energy efficient. Programs like the New York City Carbon Challenge is a great idea to get the whole city like schools, hospitals, and organizations involved in reducing greenhouse gas emissions. This challenge includes efforts from the private and public sector to help the city meet its goal of 80% reduction by 2050. “Since 2007, 17 of New York City’s leading universities, the 11 largest hospital organizations, 11 global companies, and 18 residential management firms have accepted the NYC Carbon Challenge, pledging to voluntarily reduce their building-based emissions by 30 percent or more in just ten years”. With more citywide and individual efforts, New York City will be able to reach its goal by 2050.

Also from chapter 4, the East Side Coastal Resiliency project is a great example of a policy plan New York City has done, with multiple benefits. Not only will the levee protect against storm surge and sea level rise due to climate change, but it is also a sustainable urban planning option. Greenery and public parks contribute to reducing greenhouse gas emissions, and provide a place for people to go. It is smart to build multi-purpose parks like this, as they aid in building urban and social resiliency and contribute reducing to greenhouse gas emissions. Building neighborhood resiliency and building protection
against storm surge and flooding by forms of levees or berms is the most reliable way to spend money and provide safety for people. It reduces the future risk potential of flooding, and it also allows for community involvement and entertainment.

Even though adaption and mitigation are important in New York City, learning to live a more sustainable lifestyle and taking steps to reduce carbon emissions is the most important because human impacts, the most destructive, can be fixed. Hurricane Sandy brought new perspective, and New York City responded quickly, ready to move forward and make changes for a sustainable, healthy future.

Combating climate change certainly requires more than just New Yorkers to take up the fight. But New York City is always in the global spotlight, and therefore very well positioned to lead the way. Other cities and towns can learn from New York City's efforts and initiatives to reduce climate change and become more resilient and adaptive. It is important not only for all major cities to make changes towards a sustainable future. With global efforts, and progress towards reducing greenhouse gas emissions, cities will be better prepared and protected from the effects of climate change.
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