Resilience Planning in New York City Before and After Hurricane Sandy

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Abstract

PlaNYC was one of the early sustainability plans to incorporate climate adaptation from its onset, recognizing that New York City would need both to reduce greenhouse gas (GHG) emissions and prepare for the impacts of a changing climate. This paper examines how the City's approach to climate adaptation evolved from climate risk assessment and planning under PlaNYC to experimentation with resilience policies and, following Hurricane Sandy, the implementation of large-scale recovery, rebuilding, and resilience programs and investments. Drawing on the experience of senior City staff who oversaw adaptation and resilience efforts before and after Sandy, the paper identifies several factors that enabled sustained progress: a data-driven, science-informed, and risk-based approach to decision-making; strong coordination across City agencies; partnerships with other levels of government and private infrastructure operators; the creation of institutional structures to ensure ongoing; long-term planning, which enabled the City to act quickly when funding and political opportunities emerged; and transitioning pilots into regular government processes and activities, like building codes, zoning codes, and related actions. The paper argues that New York City's experience demonstrates the importance of building knowledge and institutional capacity for adaptation before crises occur, allowing government to not only respond to major shocks but also to create durable policy and practices to build long-term resilience.

Introduction

PlaNYC, Mayor Michael R. Bloomberg's comprehensive, strategic plan for New York City to continue to grow and thrive, was anchored around solving three critical challenges: an increasing population (almost a million New Yorkers by 2030), aging infrastructure, and climate change.[1] The latter posed significant and increasing risks for the city. New York has more than 520 miles of coastline, making sea level rise and coastal storms existential threats. The large amount of impervious areas in the city, including roadways, rooftops, and parking lots means that each inch of rain that falls across the city generates 1 billion gallons of stormwater that needs to be captured, cleaned, and discharged. These hard surfaces, which are often dark asphalt, and the city's density also contribute to the urban heat island effect, which causes temperatures in parts of New York to be almost 20 degrees Fahrenheit hotter than surrounding rural and suburban areas. All of these factors posed risks for residents, businesses, and the

[1] City of New York. (2007, April). *PlaNYC: A greener, greater New York.* Office of the Mayor, pg. 4.

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city's infrastructure, which includes approximately 90,000 miles of underground power cables, 7,000 miles of sewers, 700 combined sewer and stormwater outfalls, 200 electric substations, 17 in-city power plants, and 14 wastewater treatment plants.[2] Not to mention the more than 200,000 residents living in federally designated flood zones in 2007.

Adapting to the realities of climate change will cost billions of dollars as cities upgrade their infrastructure.[3] But effective climate adaptation depends not only on funding and physical infrastructure, but on knowledge, institutional relationships, planning processes, and governance structures.

The most durable adaptation legacy from PlaNYC is not a single project or piece of protective infrastructure. It is the administrative operating system that was created as part of the plan and has evolved since 2007. This includes a mayoral coordinating office, recurring scientific assessments, cross-sectoral and governmental partnerships, legal mandates, and a growing set of standards and regulations to bake adaptation and resilience into routine capital planning, land use, infrastructure design, community engagement, and emergency management decisions. Hurricane Sandy – and the funding it unlocked – accelerated and leveraged this system, enabling the City to respond to the disaster with greater speed and ambition and helping deliver PlaNYC's promise of a greener, greater New York.

Before PlaNYC: Early Building Blocks

New York City's climate adaptation efforts did not start from scratch in 2007; they emerged from more than a decade of scientific research, environmental advocacy, and infrastructure planning. By the time the planning process for PlaNYC began, scientists, environmental organizations, universities, and municipal agencies had already established a substantial body of regional climate science, vulnerability assessments, and initial approaches to adaptation planning.

Beginning with the New York Academy of Sciences' "The Baked Apple?" in 1996, followed by the Environmental Defense Fund's "Hot Nights in the City" report in 1999 and the Columbia University-led "Metropolitan East Coast (MEC) Assessment" in 2001, researchers identified the risks that sea-level rise, coastal flooding, higher temperatures, and changing precipitation posed to the New York region. Building on this research, the New York City Department of Environmental Protection (DEP) established a Climate Change Task Force in 2004 to assess and incorporate projected climate impacts into the planning and management of the city's water supply, sewer, and wastewater

[2] Freed, A. (2012, April 19). Testimony before the United States Senate Committee on Energy and Natural Resources [Congressional testimony]. Deputy Director, New York City Mayor's Office of Long-Term Planning and Sustainability.

[3] United Nations Environment Programme (2025). Adaptation Gap Report 2025: Running on empty. The world is gearing up for climate resilience — without the money to get there. Nairobi: United Nations Environment Programme. https://doi.org/10.59117/20.500.11822/48798

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infrastructure.[4] This effort included a partnership with climate scientists at Columbia University and NASA's Goddard Institute for Space Studies (GISS).

Overall, these efforts provided three important foundations for PlaNYC's approach to climate adaptation. First, they established a scientific foundation that identified the major climate hazards facing New York City and fostered a community of researchers and practitioners engaged in understanding and addressing those risks. Second, DEP provided an institutional precedent for how municipal agencies could translate climate science into asset-specific risk assessments and infrastructure planning. Third, they demonstrated the importance of collaboration across disciplines and institutions, foreshadowing the interagency and multi-stakeholder coordination that would become central to PlaNYC and the work of the Mayor's Office of Long-Term Planning and Sustainability (OLTPS).

Building Adaptation into PlaNYC (2006-2007)

Drafting the plan

With this work happening, it is no surprise that climate adaptation was a core focus of PlaNYC from its early days. One of the earliest outlines of the plan, drafted by the newly appointed Director of Long-Term Planning (as the position was then titled), Rohit Aggarwala, included adaptation as a standalone issue, alongside buildings, energy, and water. Aggarwala was influenced in part by a 2005 New York Times op-ed by Malcolm Bowman written in the aftermath of Hurricane Katrina that highlighted New York City's coastal risks.[5]

At Aggarwala's direction, the team responsible for PlaNYC engaged staff at DEP and the Department of City Planning, who had been working on adaptation in their respective agency roles. They also reached out to the scientists from Columbia University who were advising DEP to request a briefing on their climate projections for New York. As part of the PlaNYC planning process, a working group of City staff and external advisors was also created for adaptation.[6] This mirrored similar working groups for other core topics in the plan.

Early versions of the plan included goals for both climate mitigation (reducing greenhouse gas emissions) and adaptation;[7] however, as the team was drafting the plan, a critical challenge emerged. PlaNYC was to be anchored by time-board, measurable goals. But there was no established methodology to measure a city's preparedness for future climate risks. Unlike reducing carbon emissions by a specified percentage, adaptation involves managing multiple hazards, infrastructure systems, and uncertain future conditions and reducing risks for people, operations, the economy, and natural systems. As subsequent versions of the plan were drafted, the adaptation goal

[4] New York City Department of Environmental Protection. (2008, May 6). NYC DEP releases its climate change assessment and action plan. Press Release 08-11.
[5] Bowman, Malcolm J. (2005, Sept. 25) "A City at Sea." The New York Times.
[6] City of New York (2006, Sept. 12), Sustainability Advisory Board [Presentation], Mayor's Office of Long-Term Planning and Sustainability.
[7] Rohit Aggarwala, email to Sophia Hollander (2006, June 20).

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was removed for this reason, and adaptation actions were listed under a GHG reduction goal in the Climate Change chapter. This did not mean that the importance of or focus on climate change was minimized by staff. In an internal note discussing the rollout of PlaNYC, Aggarwala noted, "to my mind, the sea level rise chart is the single most compelling data set I've come across in this project."[8]

PlaNYC 2007

PlaNYC included three explicit actions focused on adaptation: creating an intergovernmental task force to protect the City's vital infrastructure; working with vulnerable communities to develop site-specific strategies; and launching a citywide strategic planning process for climate change adaptation, including reviewing the City's Building Code and updating the Federal Emergency Management Agency's (FEMA) flood maps for the city. Rather than prescribing a comprehensive set of investments before the necessary assessments had been completed, these actions focused on establishing the scientific foundation, institutional structures, and partnerships needed to develop and implement a citywide adaptation program. The actions also engaged a spectrum of key stakeholders, including scientists, infrastructure owners and operators, and the communities most impacted by climate change.

PlaNYC's adaptation efforts were not limited to the Climate Change chapter. Given the interdisciplinary nature of adaptation and the multiple benefits that many interventions could provide, PlaNYC included 18 additional actions in other sections of the plan that had significant adaptation benefits, even while their primary goal was to advance other objectives (see Appendix A).[9] Initiatives such as planting one million trees, increasing the city's sewer capacity, and expanding the City's Bluebelt system helped reduce heat and flood risks while also improving air and water quality and neighborhood quality of life. Through this lens, approximately 17 percent of PlaNYC's 127 actions were helping the city adapt to climate change. Had these efforts been pulled out into a stand-alone climate adaptation plan, it would have arguably been one of the most comprehensive, funded climate adaptation plans of its time.

The Creation of an Adaptation Architecture (2007-2012)

NYC Panel on Climate Change and NYC Climate Change Adaptation Task Force

The City's first dedicated, citywide adaptation staff was hired in May 2008 to oversee the adaptation portfolio in PlaNYC.[10] This role's initial focus was on establishing a common scientific baseline for adaptation work, creating institutional structures for coordinated and collective action, and understanding the impacts we faced to enable a

[8] Rohit Aggarwala, email to Frank Barry (2006, Dec 8).
[9] City of New York. (2007, April). PlaNYC: A greener, greater New York. Office of the Mayor.
[10] Adam Freed, one of the authors of this paper, was hired for this role. He served in this role for nine months before becoming OLTPS's Deputy Director, where he continued to manage this work being implemented by successive policy advisors, including Aaron Koch, Leah Cohen, and Levan Nadibaidze.

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risk-based approach. To do this, Mayor Bloomberg launched two bodies at a packed City Hall press conference in August 2008.

The New York City Panel on Climate Change (NPCC), funded through a grant from the Rockefeller Foundation, brought together climate scientists, researchers, academics, and experts from the insurance, risk management, engineering, and legal fields. Modeled on the United Nations' Intergovernmental Panel on Climate Change, the NPCC was charged with developing localized climate projections for New York City and providing technical guidance to inform adaptation planning.[11]

The New York City Climate Change Adaptation Task Force (CCATF), meanwhile, consisted of 40 public and private organizations - spanning City, State and Federal agencies and 15 private companies - responsible for owning, operating, or regulating the city's critical infrastructure.[12] Its mission was to assess the vulnerabilities of these systems and develop coordinated strategies to reduce their exposure to climate risks. Members were divided into five working groups (energy, telecommunications, transportation, waste and water, and policy) and met monthly for almost 18 months. At the start of this work, we quickly realized that adaptation was a new concept for many Task Force members, who did not understand the pace or scale of climate change and the types of actions considered "adaptation". We added an agenda item at the start of each monthly meeting from members to present on their current climate risks and how they were responding to them (e.g., deploying sandbags ahead of a heavy rainstorm, pre-positioning repair equipment for windstorms, upgrading electrical equipment to deal with warmer temperatures and increased energy demand). These discussions helped establish a common understanding of adaptation, while also creating opportunities to move beyond preparing for existing hazards to changing infrastructure planning and investment decisions to account for future conditions.

The creation of the NPCC and CCATF reflected an important recognition; that effective adaptation required both a credible scientific understanding of future climate conditions and direct engagement with those responsible for managing the infrastructure at risk. The City did not own or control many of the infrastructure systems on which New Yorkers depended, making collaboration with state and federal agencies, regional authorities, and private companies essential.

In February 2009, the NPCC released the City's first official climate change projections, covering temperature, precipitation, sea-level rise, and extreme weather events. The projections indicated that by the 2050s, average temperatures could increase by 3–5°F and sea levels could rise by 7–12 inches, with potentially greater increases under a "Rapid Ice Melt" scenario.[13] According to these projections, New York's climate could look more like North Carolina's by the end of the century than its current conditions.

The NPCC's projections were not universally embraced, reflecting some of the challenges we faced in advancing the City's adaptation agenda. Soon after the NPCC

[11] City of New York. (2008, Aug. 12). Mayor Bloomberg launches task force to adapt critical infrastructure to environmental effects of climate change. Office of the Mayor, Press Release 308-08.
[12] City of New York. (2009, June). Climate change adaptation: New York City's approach [Presentation]. Mayor's Office of Long-Term Planning and Sustainability.
[13] New York City Panel on Climate Change. (2009, Feb. 17). Climate risk information. City of New York.

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released their projections, the New York Post ran a story headlined, “Mayor’s hot-head scientists push climate ahead of jobs”.[14]

Baseline Climate and Mean Annual Changes[1]

Source: Columbia Center for Climate Systems Research

	Baseline 1971-2000	2020s	2050s	2080s
Air temperature Central range[2]	55°F	+ 1.5 to 3°F	+ 3 to 5°F	+ 4 to 7.5°F
Precipitation Central range[2]	46.5 in	+ 0 to 5 %	+ 0 to 10 %	+ 5 to 10 %
Sea level rise[3] Central range[2]	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid Ice-Melt Sea Level Rise[4]	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

1 Based on 16 GCMs (7 GCMs for Sea Level Rise) and 3 emissions scenarios. Baseline is 1971-2000 for temperature and precipitation and 2000-2004 for sea level rise. Data from National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA). Temperature data are from Central Park; precipitation data are the mean of the Central Park and La Guardia Airport values; and sea level data is from the Battery at the southern tip of Manhattan (the only location in NYC for which comprehensive historic sea level rise data are available).

2 Central range = middle 67% of values from model-based probabilities; temperatures ranges are rounded to the nearest half-degree, precipitation to the nearest 5%, and sea level rise to the nearest inch.

3 The model-based sea level rise projections may represent the range of possible outcomes less completely than the temperature and precipitation projections. See page 18 for more information.

4 “Rapid ice-melt scenario” is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic Ice sheets and paleoclimate studies. See Appendix C for further description.

Source: New York City Panel on Climate Change. (2009, Feb. 17). Climate risk information. City of New York.

Despite the Post’s skepticism, the CCATF used the projections to identify more than 100 categories of infrastructure that were potentially vulnerable to climate change and began developing adaptation strategies.[15] A central challenge was the interconnected nature of the City’s infrastructure systems. Wastewater treatment facilities relied on the electric grid, telecommunications operators depended on transportation networks to restore service following storms, and virtually every sector relied on energy and communications infrastructure to maintain operations. These interdependencies reinforced the need for a coordinated, citywide approach rather than isolated assessments by individual agencies or operators.

[14] Campanile, Carl. (2009, Dec. 7). Mayor’s hot-head scientists push climate ahead of jobs. New York Post.

[15] City of New York. (2009, June). Climate change adaptation: New York City's approach [Presentation]. Mayor's Office of Long-Term Planning and Sustainability.

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Flood maps, codes, and pilots

Another early priority was improving the information available to assess the city's exposure to coastal flooding. Flood Insurance Rate Maps produced by the Federal Emergency Management Agency (FEMA) play a central role in determining flood insurance requirements and informing building regulations and infrastructure decisions. Yet the city's existing maps had not been updated since 1983, despite substantial improvements in mapping technology, changes to the shoreline, and rising sea levels (approximately 4.5 inches between 1980 and 2007). PlaNYC called for updating these maps, but FEMA refused to fund this work. We secured funding to fly an airplane over the city over the course of several weeks to create laser generated topographical maps of New York to serve as a new baseline for FEMA's maps. We provided this data to FEMA and formally requested that they update our flood maps.[16] This technology, which is commonplace now, was so unique at this time, that the effort to generate it was featured in a front-page article in the New York Times.[17]

At the same time, the City began exploring how climate risks could be incorporated into its codes and standards. The Green Codes Task Force, convened in 2008 at the request of Mayor Bloomberg and City Council Speaker Christine Quinn, released 111 recommendations in February 2010 to improve the environmental performance and resilience of buildings.[18] Nine recommendations focused specifically on building resilience, including flood protection, maintaining building habitability during power outages, and assessing the implications of future climate conditions for building design. More than 20 additional recommendations addressing water efficiency, stormwater management, urban ecology, and energy efficiency offered resilience benefits.

The City also started piloting physical interventions to reduce climate risks. This included coating dark, flat rooftops with reflective coating to reduce the urban heat island effect (through the NYC Cool Roofs Program),[19] installing and monitoring 30 stormwater management "best management practices" to test the efficacy of nature-based strategies to manage stormwater runoff,[20] and constructing new waterfront areas at Brooklyn Bridge Park, Arvene by the Sea, and Queens West with more resilient design standards.[21] Arvene by the Sea, which factored sea level rise into its site design and elevated a majority of the 172 acres development 5 feet above the existing grade,

[16] Based on this data, we recognized that the Rockaways were more vulnerable to flooding than represented in FEMAs maps. As a result, we included them in our evacuation zones for Tropical Storm Irene, which triggered the first mandatory evacuation issued in New York City, and Hurricane Sandy; even though much of the area was outside of FEMA's designated 1-in-100-year flood zone. (Doctoroff, D. L. (2012, Dec. 11). Without PlaNYC, Hurricane Sandy's devastation would have been much worse. New York Observer.)

[17] Navarro, Mierya. (2010, May 10). With lasers and flyovers, a solar map of New York. The New York Times.

[18] Urban Green Council. (2010, February). Green codes task force: Recommendations for greening the laws and regulations governing construction.

[19] New York Post. (2009, Sept. 24). Bloomberg hypes energy-efficient rooftop painting. New York Post.

[20] City of New York. (2008, December). Sustainable stormwater management plan. Mayor's Office of Long-Term Planning and Sustainability.

[21] Doctoroff, 2012

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was largely unscathed by Hurricane Sandy while surrounding areas on the Rockaways were devastated by the storm.[22]

Many of these programs transformed into major citywide initiatives. OLTPS' initial work on stormwater was a forerunner of DEP's landmark Green Infrastructure Plan, a 20-year, $5.3 billion combination of green and grey infrastructure investments to manage stormwater and reduce combined sewer overflows.[23] Cool Roofs went from a volunteer-driven effort to a program consisting of workforce development and regulatory requirements for new and substantially renovated roofs. Today, more than 1 million square feet of rooftops a year are being coated through this effort.



Mayor Bloomberg and former Vice President Al Gore launched the NYC CoolRoofs program on the rooftop of the YMCA in Queens in May 2010. (Source: City of New York)

[22] Beck, Graham T. "The Neighborhood Hurricane Sandy Couldn't Flood." Next City, 2014

[23] New York City Department of Environmental Protection. (2010, September). NYC green infrastructure plan: A sustainable strategy for clean waterways.

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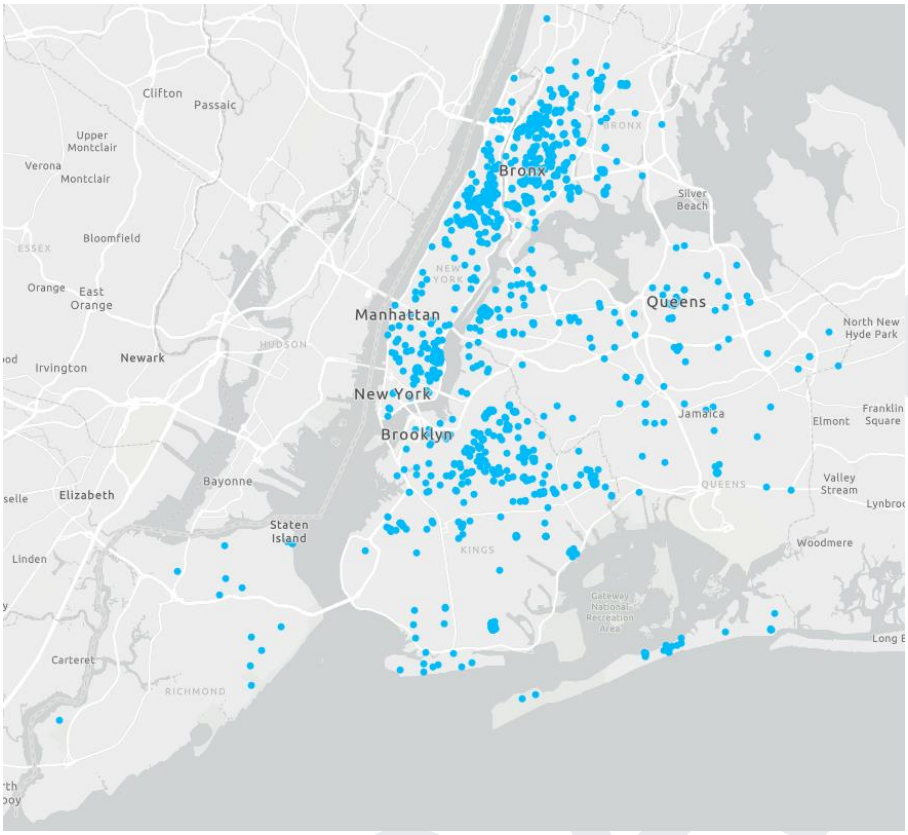

NYC CoolRoof locations as of 2026. (Source: City of New York)

These initiatives illustrate the dual nature of New York City's early adaptation efforts. On one track, we were establishing the scientific knowledge, institutional relationships, and regulatory frameworks necessary to assess and manage future climate risks. On another, agencies were implementing programs and investments that generated broader environmental and infrastructure benefits while also addressing existing vulnerabilities.

PlaNYC 2011 Update

In 2011, the City released a legally mandated update to PlaNYC, which broadened the City's climate adaptation agenda and established resilience as an explicit policy goal. Reflecting the City's increasing focus on adaptation, as well as feedback from stakeholders and members of the Sustainability Advisory Board during the update process, we added a new goal to "Increase the resilience of our communities, natural systems, and infrastructure to climate risks."[24] Unlike the City's greenhouse gas reduction goal, however, we still did not yet have a measurable target against which to

[24] City of New York. (2011, April). PlaNYC: A greener, greater New York — 2011 update. Office of the Mayor, page 150.

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assess progress. The inclusion of this goal also signaled a shift in the City's approach, from climate adaptation to resilience.[25]

PlaNYC 2011 included 11 specific initiatives focused on adaptation and resilience.[26] As with the original plan, these initiatives emphasized a science-based, data-driven approach to assessing climate risks and integrating climate projections into planning, codes, and standards. They included institutionalizing the New York City Panel on Climate Change (NPCC) and establishing a process to regularly update climate projections; developing publicly available maps of future flood exposure incorporating sea-level-rise projections; evaluating amendments to the Zoning Resolution, Building Code, and Waterfront Revitalization Program; expanding the Cool Roofs program to coat an additional two million square feet of roofs by 2013; and integrating climate change projections into the City's emergency management and preparedness plans.[27]

Resilience was again not confined to the Climate Change chapter. The update incorporated almost 30 actions across other chapters that would also increase the city's resilience to climate impacts (see Appendix B). These included implementing DEP's multi billion-dollar Green Infrastructure Plan, creating a network of green corridors, expanding the City's sewer network, restoring and creating wetlands, and developing a smarter and cleaner electric utility grid.[28]

The 2011 update did not propose large-scale coastal protection infrastructure to address storm surge and sea-level rise. Technical assessments of potential protective measures were still underway, some of the projected climate risks were perceived as longer-term challenges, and dedicated funding for large-scale coastal protection was not available (and, as demonstrated by the previously mentioned New York Post headline, would likely have faced some opposition). Instead, the plan emphasized an ongoing, flexible approach to managing climate risks, recognizing that no single intervention could adequately protect a city with such extensive and interconnected infrastructure systems. As PlaNYC stated: "Reducing the risks posed by climate change will not be achieved through a single plan or action—it must be achieved through an ongoing planning process that is responsive to the latest scientific information and a thorough understanding of the potential costs and benefits of our actions. Our strategy will remain flexible so it can be adapted to changing needs, but we are taking steps now that have tangible benefits today and will have even greater benefits as the climate changes."[29]

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[25] Resilience was defined as the "ability to withstand and recover from extreme events and environmental changes." (PlaNYC 2011, pg. 150)

[26] Actions included: Regularly assess climate change projections, Partner with the Federal Emergency Management Agency (FEMA) to update Flood Insurance Rate Maps, Develop tools to measure the city's current and future climate exposure, Update regulations to increase the resilience of buildings, Protect New York City's critical infrastructure, Work with the insurance industry to develop strategies to encourage the use of flood protections in buildings, Identify and evaluate citywide coastal protective measures, Mitigate the urban heat island effect, Enhance our understanding of the impacts of climate change on public health, Increase the city's preparedness for extreme climate events, Work with communities to increase their climate resilience

[27] Ibid, pg. 197.

[28] Ibid, pg. 154.

[29] Ibid, pg. 159.

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In September 2012, Local Law 42 was enacted, institutionalizing the NPCC and the New York City Climate Change Adaptation Task Force and establishing a legal framework for the City's ongoing climate risk assessment and adaptation planning. The law required the NPCC to update its climate projections at least every three years and the Task Force to develop an inventory of climate risks and recommend adaptation strategies within one year of the NPCC's updated projections.[30] This was an important transition from voluntary planning and coordination mechanisms to legally mandated, recurring responsibilities within City government.

One month later, Hurricane Sandy struck New York City, testing the City's preparedness and shifting the City's work from climate risk assessment and resilience planning to large-scale recovery, rebuilding, and investment.

Hurricane Sandy: A Shock and Accelerator (2012)

The Storm

On October 29, 2012, Hurricane Sandy roared into New York Harbor and the city, as well as the entire region, have never been the same. Let us start with the facts. Sandy was not what we might have thought of as a normal storm in the Northeast. By the time it made landfall north of Atlantic City, New Jersey, it had been blocked by a high-pressure system to the north and gained additional energy from a low-pressure system to the east. This not only strengthened the storm, giving in a massive windfield diameter of over 1,000 miles (three times the size of Hurricane Katrina, for comparison). It also pushed the resulting storm to the west, causing its infamous 'left hook' straight into the New Jersey coast, which put New York City directly in the path of the storm's strongest quadrant of onshore winds. This resulted in approximately nine feet (9') of storm surge (as measured at the Battery). Not only that, the storm's peak in New York City coincided with a higher than normal high tide, resulting in over fourteen feet (14') of total storm tide, nearly 40% higher than the previous record. And while the storm did not produce any notable rain or high winds in New York City, its impacts were primarily defined by this storm surge and storm tide.

In New York City alone, forty-four (44) lives were lost. The storm caused $19 billion in damages and lost economic activity. 51 square miles of the city's five boroughs – 17 percent of the total landmass – were flooded. In that flood zone, over 90,000 buildings and homes were inundated. Nearly 800 were structurally damaged or destroyed, and nearly 70,000 housing units were in buildings that suffered at least some flood damage. And over 2 million city residents were left without power, some for up to two weeks or more.[31]

All of this adds up to Sandy being the worst natural disaster ever seen in New York City. And that is where the story of a resilient recovery begins.

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[30] City of New York. Local Law 42 of 2012: A Local Law to Amend the Administrative Code of the City of New York, in Relation to the New York City Panel on Climate Change and the New York City Climate Change Adaptation Task Force. Enacted September 22, 2012.

[31] City of New York. PlaNYC: A Stronger, More Resilient New York, A report from the Special Initiative for Rebuilding and Resiliency. Released June 11, 2013.

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Resilient Innovation

It may be the most human impulse after a disaster – let us make sure 'that' never happens again. What made the response to Sandy different – what has often been referred to as its most important innovation – was the widening of how we looked at risk.

To be clear, Sandy was a coastal storm. But it was a storm that was sitting on an additional foot of sea level rise since 1900 that made its flooding worse. It was also a harbinger of things to come from climate change. Thanks to the extensive work described above that New York City advanced before Sandy, we knew that we faced climate risk and had taken decisive steps to begin planning for it. Did we see it too much as a future risk rather than a current risk? Perhaps. Sandy changed that, and the City led the way in recognizing this new reality and charting a new course to apply what was developed before Sandy and to begin the work to protect New Yorkers from the many impacts of climate change to come.

Special Initiative for Rebuilding and Resilience (SIRR)

In the weeks after Hurricane Sandy, while the response and immediate recovery efforts were still ongoing, New York City did something remarkable. It set up a new initiative to put our new climate reality at the heart of the long-term recovery effort, which we knew at the time would not only take years but would also attract billions of dollars of recovery funds. If we didn't direct that recovery to help deal with the many risks facing the city, a monumentally-important moment would be wasted.

To ensure that New York City would meet this moment, a task force led by Seth Pinsky, then the President of the NYC Economic Development Corporation, was established to chart a path forward. Critically, a team of City experts was pulled together and supplemented by outside help – notably including Marc Ricks, who had helped to manage the initial development of PlaNYC, as Chief Operating Officer.[32]

The Special Initiative for Rebuilding and Resiliency (SIRR) was launched by Mayor Bloomberg in late December 2012 and charged with answering three key questions to guide the city's long-term recovery:

1. **What happened during Sandy?** We needed a clear diagnostic effort to understand Sandy, its impacts, and its implications on New Yorkers.
2. **What could happen in the future?** We needed to put Sandy in the context of a full range of climate risks. Thanks to the New York City Panel on Climate Change, we already had a clear set of climate projections, including heat, precipitation, flooding, and sea level rise, all of which pose threats to New York City.
3. **What do we do about it?**

Answering the first two questions meant that how we respond to Sandy and plan for its long-term recovery would be not only responding to the impacts from the storm, but

[32] Daniel Zarrilli, one of the authors of this paper, was part of this task force and charged with developing the city's first-ever coastal protection plan.

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proactively preparing New York City for the full range of climate threats facing New York City, utilizing the recovery funds that were expected to be secured.

Over the course of the next six months, SIRR got to work answering those questions across a range of infrastructure systems and communities in New York City. We engaged thousands of New Yorkers, hundreds of organizations, and dozens of elected officials. We worked closely with multiple government agencies across every level of government. And we mobilized the civic leadership of New York City to guide and support this effort.[33]

Critical to getting this right was pulling forward critical work of the City prior to Sandy, much of which was described above. This also included the Urban Waterfront Adaptive Strategies (UWAS) work being led by the Department of City Planning (DCP) in their waterfront unit.[34] UWAS was an effort to identify the range of coastal typologies in New York City as well as the range of available coastal adaptation solutions that could be deployed to reduce coastal risks. It was foundational to the work of SIRR and was just one example of cross-department work by the City prior to Sandy that was immediately actionable after Sandy.

Underneath this entire effort was science. The NPCC was already in existence and had published its first projections before Hurricane Sandy. The panel was called back into service to support SIRR and ensure that our work was guided by the best available science.

The result, released in June 2013, was an off-cycle contribution to PlaNYC called *A Stronger, More Resilient New York*. This over 400-page report answered those three questions comprehensively and put forward 257 initiatives to be pursued by the City and its partners to begin the process of adapting New York City for climate change.

Federal funding ultimately became available for some of these initiatives, and over $20 billion in federal, state, city, and other funds were identified to support the implementation of SIRR initiatives, making this the largest municipal climate adaptation investment program in the US to date.

Post-Sandy Resilience (2012-2014)

SIRR Initiatives

At the conclusion of SIRR, most of the team disbanded and went back to other roles. However, Mayor Bloomberg appointed Daniel Zarrilli, a co-author on this paper, as the City's first-ever Director of Resiliency to oversee the implementation of SIRR's work. With a small but talented team housed within the Office of Long-Term Planning and Sustainability (OLTPS), we got to work.

[33] City of New York. PlaNYC: A Stronger, More Resilient New York, A report from the Special Initiative for Rebuilding and Resiliency. Released June 11, 2013.
[34] City of New York, Dept of City Planning (DCP). Urban Waterfront Adaptive Strategies. Released June 2013.

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Coastal Protection

Coastal storms are not the only climate risk facing New York City, but they can be responsible for some of the most costly damages, due to flooding. And when Sandy hit, New York City had no coastal defenses beyond some existing beaches and dunes that mostly served recreational uses, and some wetlands and similar natural areas that helped to absorb coastal energy but were not planned for that purpose. During SIRR, four strategies for improving the resilience of coastal communities were put forward: (1) Increase coastal edge elevations; (2) Minimize upland wave zones; (3) Protect against storm surge; and (4) Improve coastal design and governance. Each of these strategies were used to deal with a growing set of coastal flooding risks from sea level rise, hurricanes and nor'easters, wave action and erosion, and storm surge. SIRR also put forward a first-ever comprehensive coastal protection plan to guide future actions and investments utilizing both engineered infrastructure elements as well as nature-based solutions.

Some projects like those on the Rockaway beaches, the East Shore of Staten Island, and in Coney Island, were being led, with City support, by the US Army Corps of Engineers. These were projects that pre-dated Sandy, but had stalled for many years due to a lack of congressional appropriation, local support, or just general delays. After Sandy, the SIRR team helped reinvigorate them with local support.

Other areas did not have ongoing federal action, and while a new federal feasibility study could ultimately lead to new federal appropriations, the City decided it needed to pursue projects through different means. The federal Department of Housing and Urban Development (HUD) provided a novel pathway. Rebuild by Design and the National Disaster Resilience Competition were federal resilience competitions that provided over $1 billion for innovative projects in the Sandy-affected region. SIRR projects ultimately attracted over $500 million from this, resulting in the implementation of the East Side Coastal Resilience (ESCR) project on the Lower East Side of Manhattan to protect over 110,000 New Yorkers from storm surge, the Living Breakwaters oyster reef project to minimize wave action and erosion on the south shore of Staten Island, and the Brooklyn Bridge-Montgomery Coastal Resilience (BMCR) in Two Bridges, Manhattan to protect against storm surge.

Each of these projects demonstrates a critical element of New York City's approach to resilience. Projects have to serve a daily need, whether that is related to improved recreational space, biodiversity and water quality enhancements, or general quality of life while also providing a risk reduction benefit when needed and leverage nature-based solutions where relevant as part of the process of adapting the city.

The Raised Shorelines project was awarded $100 million from FEMA to upgrade coastal infrastructure in areas of the City that were particularly vulnerable to sea level rise and high tide flooding.

And on a shorter timeframe, certain City assets were identified for immediate deployment of interim flood protection measures to reduce risk at critical infrastructure assets.

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Infrastructure

At the same time, other important SIRR investments were being pushed forward all over the city. Thanks to the Housing Recovery Office, more than 1,300 homes have been rebuilt and elevated and tens of thousands of public housing and other apartment units made safer. Infrastructure has been renovated and was modernized to better serve New Yorkers, including major investments in the stormwater system in places like Southeast Queens or the Staten Island Bluebelt. Over $1 billion was secured to make critical upgrades to the electric grid. A large innovative FEMA grant was secured to protect City-owned hospitals, including a new elevated emergency department at Coney Island Hospital. And heat mitigation measures like street trees and white rooftops were accelerated in heat-vulnerable neighborhoods.

Critical to all of this work was the continued support of the NPCC to ensure that the best available science supported ongoing implementation of these important climate adaptation projects. And bodies like the Climate Change Adaptation Task Force were used as important forums to continue to bring together the civic leadership of New York City's infrastructure owners to coordinate planning and investments.

A Period of Transition

The first six months of SIRR implementation coincided with the last six months of the Bloomberg Administration. What was apparent at the time was the need to demonstrate immediate progress to insulate this nascent climate adaptation and resilience effort from the political cycles of the City.

When Mayor de Blasio took office in January 2014, the recovery from Sandy loomed large. Housing recovery efforts were perceived to be moving forward too slowly. And federal help for both housing and infrastructure recovery was slow in arriving.

In March 2014, Mayor de Blasio put his imprint on this recovery by changing leadership at the Housing Recovery Office and, importantly for our resiliency efforts, greatly expanded the resiliency team under a new Office of Recovery and Resiliency to continue the SIRR implementation.

It was in this period of mayoral transition, from June 2013 onward, that New York City embraced the challenge of climate adaptation across mayoral administrations and put resilience at the heart of the continuing long-term recovery from Sandy.

What did this look like? It meant pushing forward the SIRR initiatives and putting New York City on the forefront globally of climate adaptation, thanks to over $20 billion of investment that had been identified and launched by New York City. And as PlaNYC transitioned into OneNYC in April 2015, incorporating equity as a new guiding principle strengthened our resilience work.

From Resilience Projects to Resilient Institutions (2014-onward)

In the next phase of New York City's resilience journey, it was obvious early on that federal investment and major infrastructure projects could not be funded indefinitely.

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The path to resilience would instead need to transition away from an effort dominated by projects to one dominated by mainstreaming resilience into every City action and decision.

Resilience was baked into building and zoning codes to change how and where we build. Some communities have experimented on a small scale with managed retreat. New legislation was enacted requiring a regular, comprehensive five-borough climate adaptation plan. New climate resilience design guidelines for City-funded projects were developed to incorporate climate-smart planning into capital projects. And in 2019, the City elevated the prominence of climate action and resilience as the heart of its long-term strategic plan, OneNYC 2050. Sandy put us on this path toward resilience.

More Disasters

The years after Sandy were not without disruption, validating the approach taken to prepare for a wider range of climate risks after Sandy. A citywide stormwater resilience plan was released in May 2021. Months later, Hurricane Henri dropped over 2" of rain in an hour – a new record – and then only two weeks later Hurricane Ida dropped over 3" of rain in an hour – a new record by 50% – on the city, flooding inland neighborhoods and killing 13 New Yorkers, many of whom drowned in basement apartments. More storms since then have exceeded that 2" rainfall intensity record in the years since. Heat continues to kill more New Yorkers than any other natural hazard every year, and New York City in 2018 released a first-ever heat resilience plan to better prepare New Yorkers for a warmer city. And distant Canadian wildfires have twice turned our skies orange.

These ongoing climate disruptions, which can and will continue to threaten New York City, will also continue to demonstrate the need for not letting up on the work of adaptation and resilience. Thankfully, over two decades of planning and implementation have given New York City the tools to succeed.

Lessons from NYC

The process of developing and implementing PlaNYC and the recovery and rebuilding efforts from Hurricane Sandy illustrate several critical lessons. Centering the City's adaptation efforts around science and giving infrastructure operators and policymakers direct access to scientific and risk management experts ensured that we were taking a data-driven, risk-based approach to adaptation and resilience. The uncertainty inherent in the projections did not prevent action but allowed us to identify clear no-regret near-term actions, like Cool Roofs and green infrastructure, while planning for longer-term risks.

The cross-cutting impacts of climate change across every facet of city life necessitated both coordination and collaboration between City agencies (like DEP, which is responsible for capturing and treating stormwater, and the NYC Department of Transportation, which is responsible for roadways that generate stormwater runoff) and external partners. The CCATF and the SIRR showed the value of this coordination, and how important it is to nurture it before a crisis. Researchers from the London School of

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Economics found that in the aftermath of Sandy, New York "capitalized on its pre-established awareness of climate change risks. This allowed swift, coordinated action stemming from the Mayor's Office, which ultimately allowed for controlling against excess loss of lives and economic damage, as well as securing post-event funding from the federal government and other resources."[35] One of the City staff they interviewed noted that Sandy "'wasn't an event that caused the city to change its plan or policy', rather than shocking city government, [it] activated prior planning efforts for both emergency response and the long term."[36]

Hardwiring our work into the structure of municipal government was also critical, given the long timeframes required to adapt the city's infrastructure and make the significant changes needed in the face of climate change, especially as these changes span political terms. In 2008, OLTPS was established as a permanent part of New York City government, and the City was legally required to update its long-term sustainability plan at least once every four years. Following this model, in 2012 we institutionalized the NPCC and CCATF and required regular updates of the city's climate change projections.

Rapidly testing ideas and converting what worked into codes and standards also enabled us to scale solutions and leverage the City's multi-billion dollar capital budget for adaptation. Initial pilots on green infrastructure, cool roofs, and living shorelines were mainstreamed through codes and design standards like the Cool Roof Ordinance and Green Parking Lot Code.

Our work demonstrated that adaptation capacity is a cumulative effect, driven by consistent and long-term investments, and the importance of adapting institutions, not just the physical environment.

Conclusion

New York City's climate adaptation efforts, which were jumpstarted by PlaNYC, cannot be viewed as a single plan, policy, or response to an event. Rather, they reflect an evolving approach that built upon successive efforts to understand climate risks, develop institutional capacity, and translate scientific knowledge into government action. DEP's Climate Change Task Force provided an early model for data-driven, risk-based infrastructure planning. PlaNYC and the creation of OLTPS elevated adaptation to a citywide priority, while the NPCC and CCATF established mechanisms for ongoing scientific assessment and coordination across sectors and levels of government. The 2011 PlaNYC update broadened the City's focus from adaptation to resilience and expanded efforts to integrate climate risks into municipal policies and planning. Hurricane Sandy and the subsequent SIRR provided the urgency, political focus, and

[35] McCraine, S., & Surminski, S. (2019, November). Understanding decisions and disasters: A retrospective analysis of Hurricane Sandy's 'focusing power' on climate change adaptation policy in New York City. Grantham Research Institute on Climate Change and the Environment, Working Paper No. 328. London School of Economics and Political Science.

[36] Ibid

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funding to accelerate large-scale resilience investments, while OneNYC brought greater attention to equity as a core consideration in resilience planning.

Sandy demonstrated the importance and the limitations of the City's preparedness. Studies were progressing prior to 2012, but these had not yet translated into major infrastructure projects for coastal protection. While substantial vulnerabilities remained, the scientific research, institutional relationships, and planning undertaken before the storm positioned the City to respond more quickly and comprehensively when political urgency and funding became available.

This underscores the importance of building adaptation capacity before a crisis occurs, even when the resources or political support for large-scale investments are not yet in place. Former Deputy Mayor Dan Doctoroff, who oversaw the development of PlaNYC observed, "PlaNYC made New York better prepared than ever for a major event like Sandy—even though the hundred-year storm we were planning for came all too soon. Mayor Bloomberg's most lasting legacy won't be a single park or cultural site—it will be his vision for a city prepared to survive and thrive in a world of new competition, threats and dangers."[37]

Ambitious plans are necessary, but they are not sufficient. The more consequential outcome than releasing a plan is building the institutions, partnerships, policies, funding mechanisms, and accountability needed to translate long-term goals into sustained action. Our experience shows that these changes may be less visible than major infrastructure projects, but they are essential to advancing the broad range of changes and public and private investments needed to adapt to climate change.

[37] Doctoroff, 2012

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Appendix A: Actions in other chapters with adaptation benefits in PlaNYC (2007), by climate hazard

Extreme rainfall and flooding

- Open schoolyards as public playgrounds
- Green the cityscape (plant 1 million trees across the city; convert 240 paved traffic areas into greenstreets)
- Convert asphalt sites into multi-use turf fields
- Expand wet weather capacity at treatment plants
- Increase use of high-level storm sewers
- Expand the Bluebelt system
- Require green parking lots
- Form an interagency BMP Task Force
- Pilot promising BMPs
- Provide incentives for green roofs

Drought

- Launch a major water conservation effort
- Evaluate new water sources
- Continue the Watershed Protection Program

Heat

- Open schoolyards as public playgrounds
- Green the cityscape (plant 1 million trees across the city; convert 240 paved traffic areas into greenstreets)
- Expand Peak Load Management
- Accelerate reliability improvements to the city's grid
- Support Con Edison's efforts to modernize the grid
- Reforest targeted areas of our parkland
- Increase tree planting on lots
- Require green parking lots
- Provide incentives for green roofs

Sea level rise and coastal flooding

- Protect wetlands

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Appendix B: Actions in other chapters with adaptation benefits in PlaNYC (2011), by climate hazard

Extreme rainfall and flooding

- Foster the creation of Greener, Greater Communities
- Increase the sustainability of City-financed and public housing
- Maintain and upgrade dams
- Increase operational efficiency with new technology
- Create a network of green corridors
- Plant one million trees
- Support ecological connectivity
- Complete cost-effective grey infrastructure projects to reduce CSOs and improve water quality
- Expand the sewer network
- Optimize the existing sewer system
- Expand the Bluebelt program
- Build public green infrastructure projects
- Engage and enlist communities in sustainable stormwater management
- Provide incentives for green infrastructure
- Enhance wetlands protection
- Restore and create wetlands

Drought

- Maintain and upgrade dams
- Increase water conservation
- Incorporate sustainability through the design and maintenance of all public space

Heat

- Implement the Greener, Greater Buildings Plan
- Improve our codes and regulations to increase the sustainability of our buildings
- Improve compliance with the energy code and track green building improvements citywide
- Improve energy efficiency in smaller buildings
- Improve energy efficiency in historic buildings
- Provide energy efficiency financing and information
- Support cost-effective repowering or replacement of our most inefficient and costly in-city power plants
- Encourage the development of clean distributed generation
- Foster the market for renewable energy in New York City
- Ensure the reliability of New York City power delivery
- Develop a smarter and cleaner electric utility grid for New York City

Sea level rise and coastal flooding

- Enhance wetlands protection
- Restore and create wetlands

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