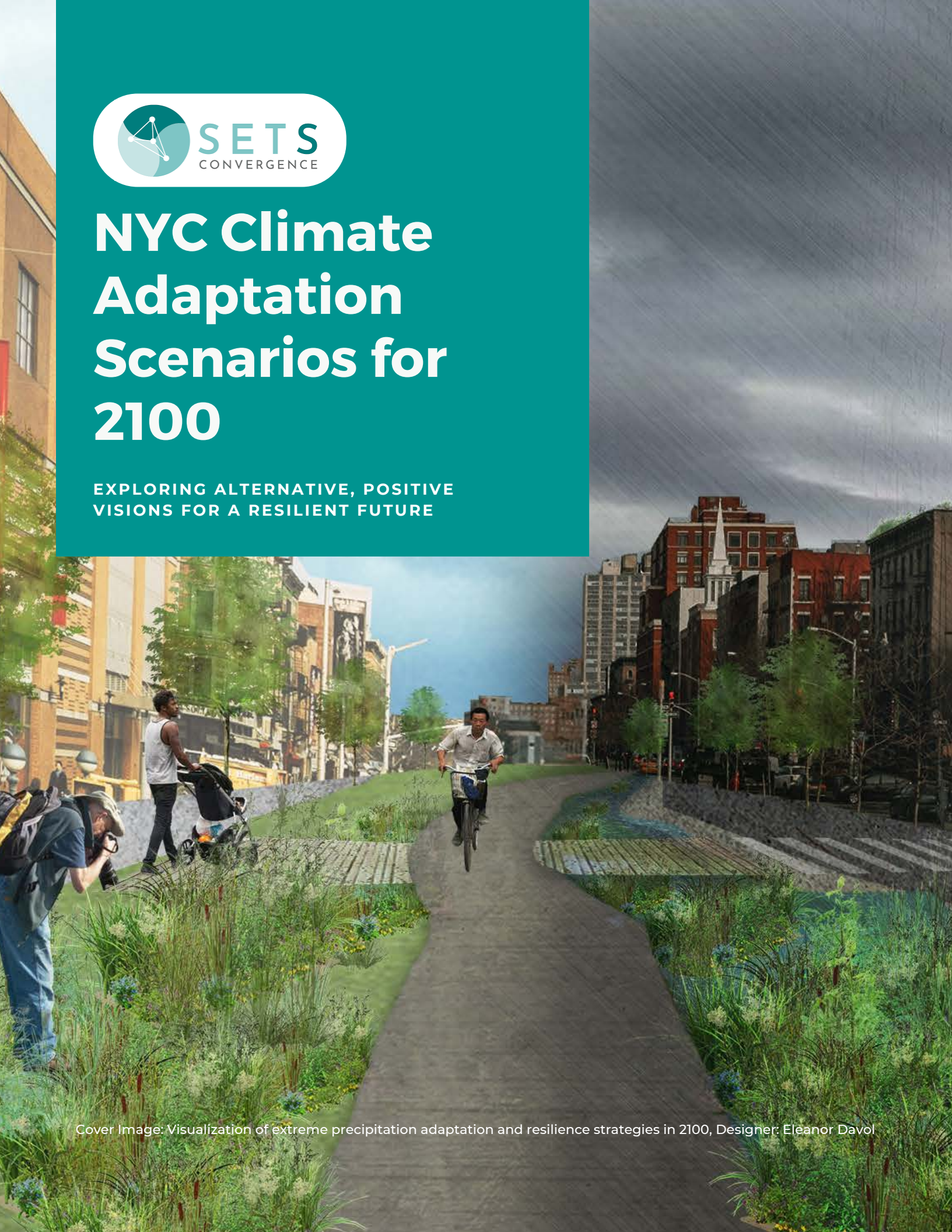
SETS CONVERGENCE

NYC Climate Adaptation Scenarios for 2100

EXPLORING ALTERNATIVE, POSITIVE VISIONS FOR A RESILIENT FUTURE



Cover Image: Visualization of extreme precipitation adaptation and resilience strategies in 2100, Designer: Eleanor Davol

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Workshop Summary

In the face of global climate change, city governments must anticipate and guide decisions in response to extreme weather-related events, including coastal and inland flooding, heat waves, multi-hazard risks, drought, and winter extremes. With the goal of addressing this challenge, between Sept. 24 - Oct. 22, 2021, the National Science Foundation (NSF) Social-Ecological-Technological Systems (SETS) Convergence Research Network partnered with the New York City (NYC) Mayor's Office of Climate and Environmental Justice (MOCEJ) to facilitate the NYC Climate Adaptation Scenarios workshop series, a wide ranging yet structured set of anticipatory discussions on future climate resilience and adaptation[1]. Through a series of five 3-hour virtual workshops, diverse participants co-developed positive future visions for New York City of sustainability, resilience, and adaptation to climate change and extreme events.

Approximately 35 government practitioners from 24 city, state, and federal agencies gathered virtually over the course of five weeks (see Table 1 for agencies involved). Together, participants **co-developed six distinct climate adaptation scenarios**. The goal of each future scenario was to radically transform the city's social, environmental, and physical infrastructure—including governance, green infrastructure, and water-energy-transit systems—and the city's ability to respond to extreme events.

Participants worked in small groups to envision six scenarios for the future of New York City in 2100. The envisioned future scenarios addressed: **Multiple co-occurring hazards, Coastal flooding, Extreme heat, Winter extremes, Extreme precipitation, and Drought and shifting water demand**. Scenario themes were developed in response to practitioner concerns and the city's sustainability and environmental management plans. Through a series of workshop and post-workshop activities, including innovative ideation, timelines, visual illustrations, and day-in-the-life narratives, participants defined long-term goals and strategies for each scenario to develop radical visions for New York City in 2100. Existing NYC climate governance and strategies were seeded as a starting point to inform scenario development and build on visionary work already happening in the city.

Figure 1. Goals of scenario planning

Why did we do this? Without shared positive visions for the future we want, it is unlikely that plans we make now will achieve the equity, justice, sustainability, and resilience goals we have for our city and society. In order to create space for positive visions to occur, we have to imagine time frames far enough into the future that we can ignore the tyranny of the present demands and constraints that often make it hard to imagine the future we want. Existing planning efforts often focus on goals that are only 10, 20, or possibly 30 years into the future, yet many of our aspirations will take even longer to achieve, even if we start on those transformative pathways now. **We used a 2100 timeframe of approximately 80 years from today to create a rare space for long-term planning and positive visioning**. Ultimately, the workshop activities were designed to develop long-term future visions that imagine what the future ought to be and consider more transformative strategies to achieve those visions without being constrained by the inner workings of the current sy

ABOUT THE CONVERGENCE PROJECT

The Converging Social, Ecological, and Technological Infrastructure Systems (SETS) for Urban Resilience Project is a multi-year initiative funded by the National Science Foundation to provide cities with the knowledge and methods for building integrated resilience strategies to extreme events, supported by cutting-edge modeling, simulation, and visualization of infrastructure systems.

The Convergence project seeks to address urban resilience to climate risks such as heat, drought, and floods and is based in collaborations with local stakeholders, decision makers, and researchers in New York City, Atlanta, Phoenix, and San Juan, Puerto Rico.

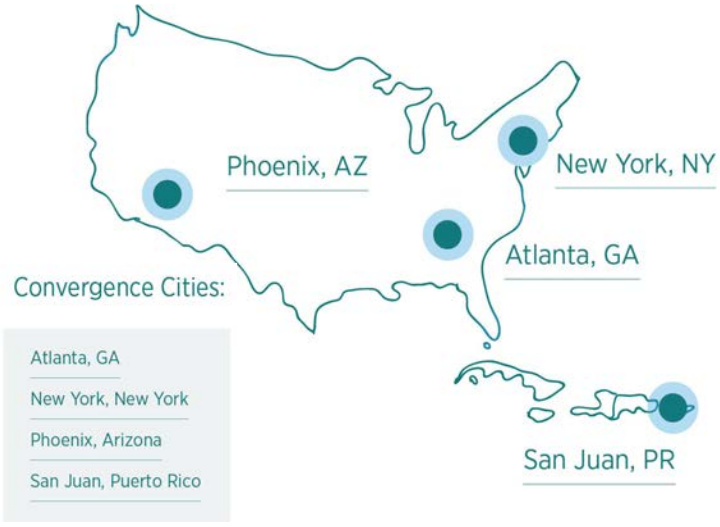


Figure 2. Convergence Project cities

[1] The SETS Convergence Research Network is sponsored by the National Science Foundation (NSF) Grant Number 1934933 to support urban planning and development by generating future scenarios through a participatory process that seeks to achieve transformative changes in urban resilience.

Scenario Development Process

To initially frame the integrated dimensions of cities, the SETS Convergence team uses a framework of cities and infrastructure as interdependent social, ecological, and technological systems (SETS). Workshop participants began by considering the projected environmental conditions in 2100 and their impact on interacting SETS dimensions of New York City. Working in small groups, the participants then worked through a **series of activities to envision six positive future scenarios for a New York City in 2100 that is more just, equitable, and resilient in the face of climate challenges**. The participants deliberated overarching scenario goals, and discussed social, environmental, and engineered strategies for adaptation and resilience interventions to achieve their visions.

We co-developed six scenarios in a series of five virtual workshops based on the following questions:

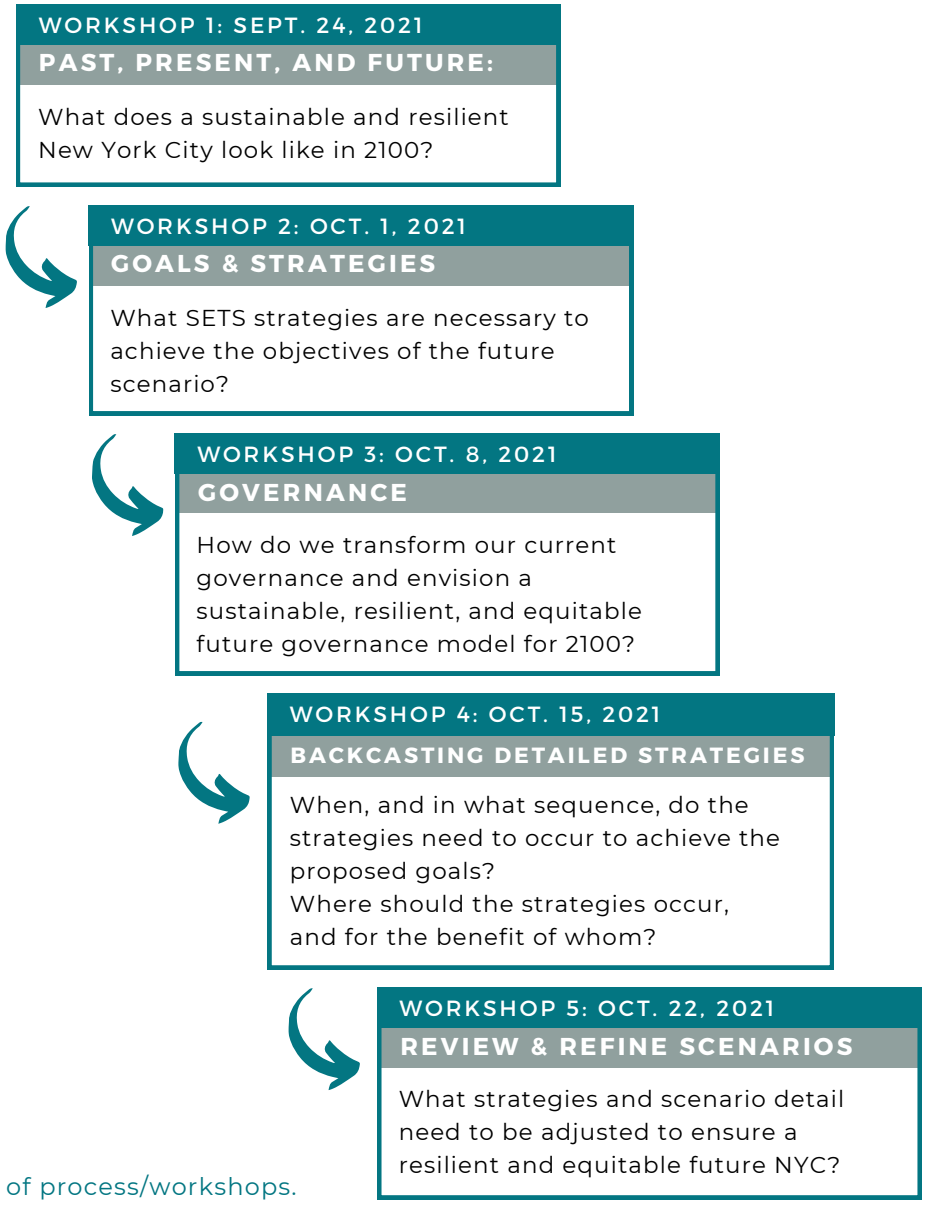


Figure 3. Overview summary of process/workshops.

TABLE 1: PARTICIPATING AGENCIES

New York City, State, and Federal agencies participated in the workshop series, including:

- Economic Development Corporation (EDC)
- Federal Emergency Management Administration (FEMA)
- New York City (NYC) Dept of Buildings (DOB)
- NYC Dept of City Planning (DCP)
- NYC Dept of Design and Construction (DDC)
- NYC Dept of Environmental Protection (DEP)
- NYC Dept of Health and Mental Hygiene (DOHMH)
- NYC Dept of Housing and Preservation Development (HPD)
- NYC Dept of Parks and Recreation (Parks)
- NYC Dept of Sanitation (DSNY)
- NYC Dept of Transportation (DOT)
- NYC Emergency Management (NYCEM)
- NYC Housing Authority (NYCHA)
- NYC Law Department
- NYC Mayor's Office of the Chief Technology Officer (MOCTO)
- NYC Mayor's Office of Climate and Environmental Justice (MOCEJ)
- NYC Mayor's Office of Climate Resiliency (MOCR)
- NYC Mayor's Office of Climate Sustainability (MOCS)
- NYC Office of Management and Budget (OMB)
- NYC Police Dept (NYPD)
- NYC School Construction Authority (NYCSCA)
- New York State (NYS) Dept of Transportation (NYSDOT)
- NYS Energy Research and Development Authority (NYSERDA)
- Port Authority New York New Jersey (PANYNJ)
- United States Army Corps of Engineers (USACE)

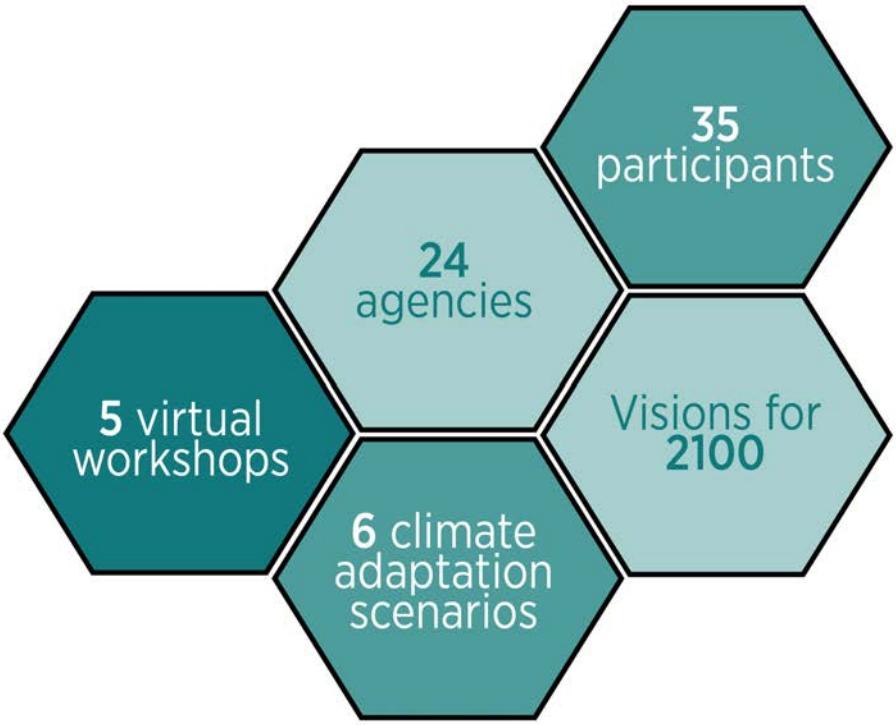


Figure 4: Workshop series overview

Social-Ecological-Technological Systems (SETS)

Many of the challenges we face today, such as climate change, social inequality, or environmental health, cannot be solved by traditional, often siloed planning approaches. These are complex problems with high levels of uncertainty that require the integration of different perspectives, experiences, and knowledge. One planning and governance challenge of cities like New York is how to build resilience to extreme weather-related events and climate change that endangers lives, communities, ecosystems, and infrastructure in such complex urban systems. When cities are resilient, they can persist, grow, and even transform, maintaining their functions and identity. Yet, building resilience in one sector, scale, or subsystem can create unintended trade-offs, requiring systems approaches to integrate and coordinate resilience innovations (Elmqvist et al. 2019). The social-ecological-technological systems (SETS) conceptual framework integrates multiple dimensions of cities and their feedbacks and interactions (Grimm et al. 2015; McPhearson et al. 2016; Markolf et al. 2018; McPhearson, Cook et al. 2022). SETS thinking is seen as an essential approach to promote resilience in complex cities and facilitate their transformation towards more sustainable futures.

The social dimension of SETS includes diverse perspectives of communities and decision-makers, along with the governance, culture, and economic dimensions of the city.

The ecological dimension includes elements of nature that are part of the fabric of cities, including aquatic and terrestrial species, communities, and ecosystems. The technological dimension includes the built components of cities, for example, the road system, public transportation systems, building infrastructure, and energy and water networks, as well as diverse forms of technology.

Perhaps the most important feature of SETS framework is that it is a systems approach. This means that the social, ecological and technological elements are not considered separately. Rather, these elements are considered together with special attention to the relationships, interactions, and feedbacks between the three dimensions.

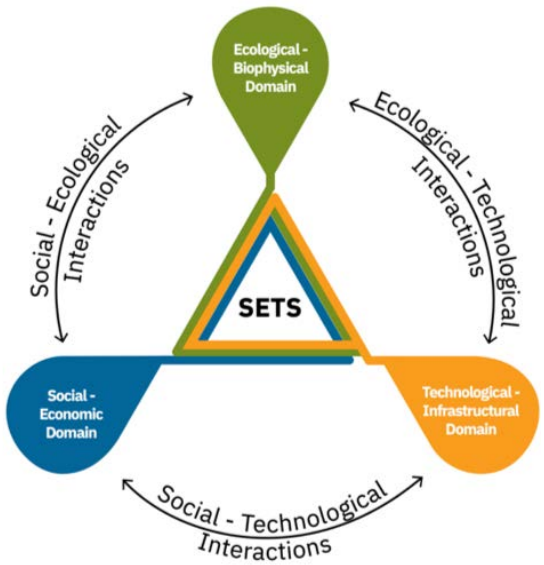


Figure 5. Social, Ecological, and Technological Systems (SETS) diagram.

Scenario Cross-Cutting SETS Themes

Through five virtual workshops, participants from diverse sectors and local, regional, and federal agencies developed long-term (2100) future goals for each theme, along with strategies and governance approaches to achieve those goals.

Throughout the workshop series, participants were prompted to consider whether their goals addressed cross-cutting challenges such as equity, governance and political will, ecosystem-based and engineered solutions, and power, energy, water, and transit systems.

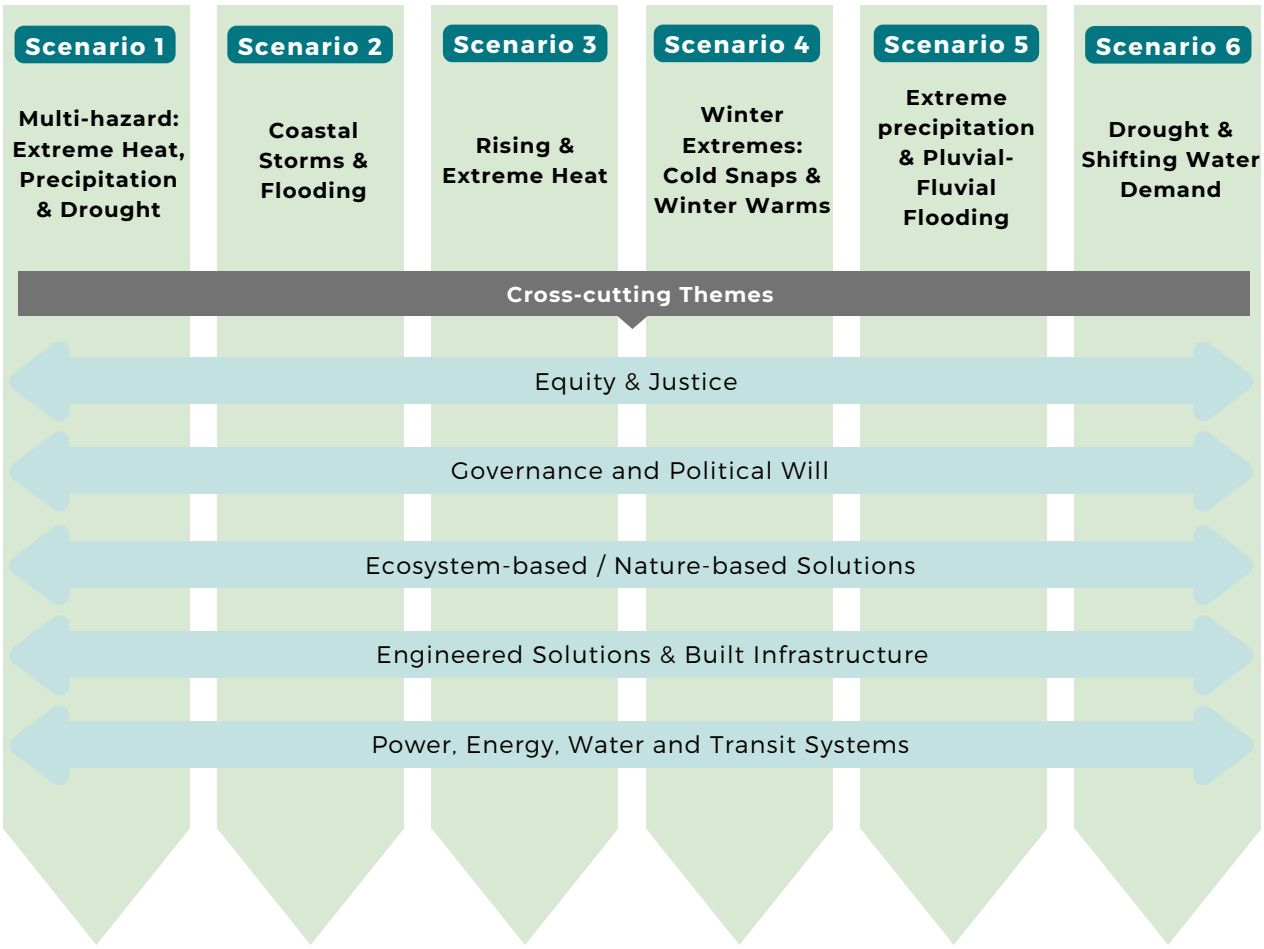


Figure 6. Six co-produced scenarios for NYC Climate Adaptation Futures

NEW YORK CITY CLIMATE ADAPTATION SCENARIOS WORKSHOP SERIES

Summary of Climate Adaptation Scenarios for 2100

New York City 2100 Future Visions

The co-developed future scenarios we summarize here addressed environmental hazards including **Multiple co-occurring hazards, Coastal flooding, Extreme heat, Winter extremes, Extreme precipitation, and Drought and shifting water demand**. The scenarios had several objectives in common including cross-jurisdictional governance and equitable access for all New Yorkers to the safe and resilient futures proposed.

Each future vision described below was developed collaboratively during the NYC Climate Adaptation workshop series. The ideas presented here are a synthesis of the participant conversations during the workshop series—and incorporate ideas and input from many different sectors, disciplines, and perspectives.

While the ideas and strategies may not be fully developed, and are certainly not final, they are shared as co-developed aspirational visions for 2100 (and in many cases sooner) and we encourage and hope for their further development to ensure New York City's communities, infrastructure, ecosystems, and governance are adaptable and resilient in the face of future climate change.

The following section includes a synthesis and description of the goals, strategies, and targets developed in each scenario.

Figure 7: Lower Manhattan, New York City. Photograph: Shutterstock

SCENARIO 1

Addressing multi-hazard events by 2100: Extreme heat, flooding, and drought

New York City is susceptible to multiple hazards that create new and complex risks such as from co-occurring and sequential events of extreme heat, flooding, and drought. These multi-hazard interactions can exacerbate impacts and risks and have compounding consequences on communities, ecosystems, and infrastructures. Responding to co-occurring emergencies puts a strain on governance capacities and increases levels of stress and trauma for communities. Multi-hazard events are likely to increase over the coming decades and suggest the need to develop systemic solutions that address multiple sources of risk.

A future New York City that is resilient to multi-hazard risks from extreme heat, precipitation, and drought is envisioned to have **reliable, resilient, and interconnected infrastructure** that addresses multiple risks and combines green and gray infrastructure solutions. The future city would have a **social contract that establishes an inclusive and transformative governance system** built on principles of trust, agility, and accountability and integrates community participation, expertise, and cross-agency collaboration to better address future co-occurring hazards. All New Yorkers would have **equitable access to physical health, mental well-being, and economic stability** that is not dependent on zip code, race, and privilege in order to be better equipped in the face of future events.

Goal 1: Reliable and resilient infrastructure that addresses multiple risks

- Develop fully resilient energy grid with increased renewables
- Establish a publicly owned power generation system
- Invest in redundancy
- Invest in a green, community-based economy
- Identify funding streams
- Enforce multi-hazard design requirements
- Fortified transit system to safely move people during hazards

Goal 2: Social contract for inclusive and transformative governance

- Compensate community partners equitably
- Create forums for community relationships
- Develop grading system of elected officials to improve accountability
- Improve transparency of roles, responsibilities, and information and data sharing across agencies
- Increase community involvement in operations and maintenance of local assets
- Establish resiliency hubs
- Hold discussions and initiate mechanisms for communities at risk to retreat from coastal hazards

Goal 3: Equitable access to physical health, mental well-being, & economic stability

- Create one-payer health system
- Expand equitable access to affordable, high quality mental health services
- Guarantee access to energy for heating and cooling
- Ensure equitable distribution of and access to critical facilities and high quality, essential services such as schools and hospitals

Multi-hazard Descriptive Synthesis

Goal 1: Reliable and resilient infrastructure that addresses multiple risks

This goal focuses on a systems approach to resilient infrastructure in order to harness and improve interconnected green and gray infrastructure systems, such that infrastructure continues to function during single and co-occurring events.

This goal acknowledges the significant uncertainty of multiple co-occurring hazards, including their potential impacts and effects on the design of infrastructure. In this goal, design guidelines of infrastructure systems are re-vamped to build resilience and adaptive capacities, including redundancy, agility, safe-to-fail principles, and sustainability.

Participants envisioned future infrastructure, including use of renewable technologies and nature-based solutions, that will be interconnected and enable flexibility during co-occurring events. The interconnected systems will allow safe failure or a minimum service provisioning that avoids complete failures. Specific strategies and targets to achieve this goal include:

Governance and social infrastructure

- Investment in infrastructure and institutional redundancy
- Investment in green and community-based economy with jobs guarantee & CUNY/SUNY pipeline
- Identify more reliable funding streams to build, maintain, and retrofit infrastructure

Energy infrastructure

- Development of fully resilient energy grid with significant increase in renewables
  - Maximize solar energy production on building roofs where possible by 2090
  - Maximize wind energy production on near shore areas by 2100
  - Introduce regulatory reform to change incentives (e.g., grid currently run by companies that have profit as end goal which is disincentive for long-term investments in hardening the grid against climate threats)
- Installation of hydropower generation in wastewater system in order to generate enough capacity to self-power sewer and wastewater system
- Cogeneration of power via publicly owned power generation system

Building retrofits

- Building codes and policies with multi-hazard design requirements including by 2040, 100% of new buildings and major renovations to meet requirement

Transportation infrastructure

- Replace all city heavy duty vehicles with electric vehicle (EV) options and/or super low greenhouse gas emitting biofuels by 2060
- Transportation system focused on safely moving people, not managing cars
- Create long-term plan to build electric vehicle transmission into the major highway and bridge maintenance cycle by 2035
  - 50% of major highways to allow for powering electric vehicles in at least 50% of available lanes by 2060;
  - 100% of major highways to allow for powering electric vehicles in at least 50% of available lanes by 2080.

Coastal infrastructure

- Identification of soft and hard shorelines to adapt and elevate and which areas may be part of longer-term retreat discussions by 2025
  - Adapt 50% of low-lying hard shorelines to meet the 90th percentile 2080s Sea Level Rise projections; be ahead of schedule by 2045
  - Adapt 100% of low-lying hard shorelines to meet the 90th percentile 2080s Sea Level Rise projections by 2070
- Restoration and adaptation of existing at-risk salt marshes and soft shorelines
  - At least 50% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s SLR projections by 2045
  - Restoration of 100% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s SLR projections by 2070

Goal 2: Social contract

This goal focuses on inclusive and transformative governance with multi-level, flexible, and adaptable governance systems that foster trust between government & residents, city & state, community & individuals.

This future goal envisions moving toward a future where communities are thriving and moving away from a constant state of reaction and recovery that multiple and cascading hazards may bring. Workshop participants envisioned a relationship-focused, multi-level governance model for a resilient NYC. This new mode of governance is anchored on a social contract that builds trust between government and communities through inclusivity, transparency and accountability.

Communities in 2100 will be able to trust that the government is following through on mitigation and adaptation commitments and that the government will respond effectively for their safety, regardless of their zip codes. Communities will be active participants in this governance structure because their vision, expertise, and involvement in government projects are respected and valued. Communities and municipal agencies have a learning partnership and commitment to be anticipatory by co-producing preparedness trainings and adaptation plans.

Municipal governance will no longer be defined by short-term visions and project-specific budgeting structures tied to political cycles. Instead, governance is guided by a long-term vision that is defined by the community, supported by larger and agile discretionary budgets to meet those objectives, and elected officials that execute and are accountable for that vision through a regular review system. Specific strategies and targets to achieve this goal include:

Supporting community participation and leadership in long-term planning

- Equitable compensation for community organizations and individuals for their expertise and participation in governance
- A new budget system that includes community participation in budget decision-making
- Forums for building and maintaining community relationships without a specific agenda (e.g. proactive relationship maintenance)
- Increased community involvement in operations and maintenance of local assets through partnerships with government and utilities

Supporting interagency collaboration and government accountability

- Collaborative interagency relationships with agile, effective sharing of skills, data, and staff with transparency during multiple events. Roles and responsibilities are anticipated and clearly defined across agencies prior to an emergency.
- Grading/review system of elected officials to build accountability throughout their terms and inform future action

Supporting resilient communities

- All communities by 2030 will have resiliency hubs that can support, educate, and provide resources for multi-hazard resilience. In this case, resiliency hubs were envisioned as physical community spaces, such as libraries, that can support communities in preparation, recovery, and resilience during extreme events.
- Building and maintaining trust to have honest conversations about retreat including beginning discussions with at-risk communities by 2030 and initiating retreat mechanisms by 2040

Goal 3: Equitable access to physical health, mental well-being, & economic stability

This goal of improved physical, mental, and economic well-being addresses hazard trauma and is equitably applied across the city and thus independent of zip code, race, and privilege.

The focus of this goal is to ensure all NYC communities thrive in, rather than simply survive, climate extreme events. The workshop participants envisioned strong social and economic safety nets as critical components to achieve this goal. In this future, there is a strong foundation for community resilience, including health care for all, equitable access to reliable infrastructure and public services, social cohesion, and opportunities for education and social mobility. Residents rely on the government to assure their safety during emergencies. Yet, due to the significant investment in hyper-local capacities and resources, fewer government resources need to be directed towards risk mitigation and emergency planning and recovery, hence promoting sustainability. Specific strategies and targets to achieve this goal include:

Health care

- 100% healthcare access by 2080 including creation of one-payer health system (no longer "health industry")
  - One-payer health system has 70% adoption rate by 2060;
  - 100% healthcare access by 2080 and equitable access for all New Yorkers
- Improve access to NYC Health and Hospitals Corporation (HHC) clinics and quality of care as initial mechanism to improve affordable access by 2025

Climate resilient housing and social safety nets

- Affordable and safe housing for all
- By 2100, 0% homelessness and 100% access to resources for mental health needs
- Mechanisms to improve community resiliency without displacement
- Reform insurance system toward existing government coverage by 2030
- Create minimum guaranteed access to energy for heating/cooling

Community resilience and resources

- Build schools/hospitals/mixed use districts evenly across the habitable areas
- Youth education programs on climate action

Timeline: Resilience to Multi-Hazard Events

Timelines for addressing the Multi-Hazard Event (Extreme Heat, Flooding, and Drought) adaptation and resilience goals: Workshop participants developed a detailed near-term (present day to 2035) and a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals.

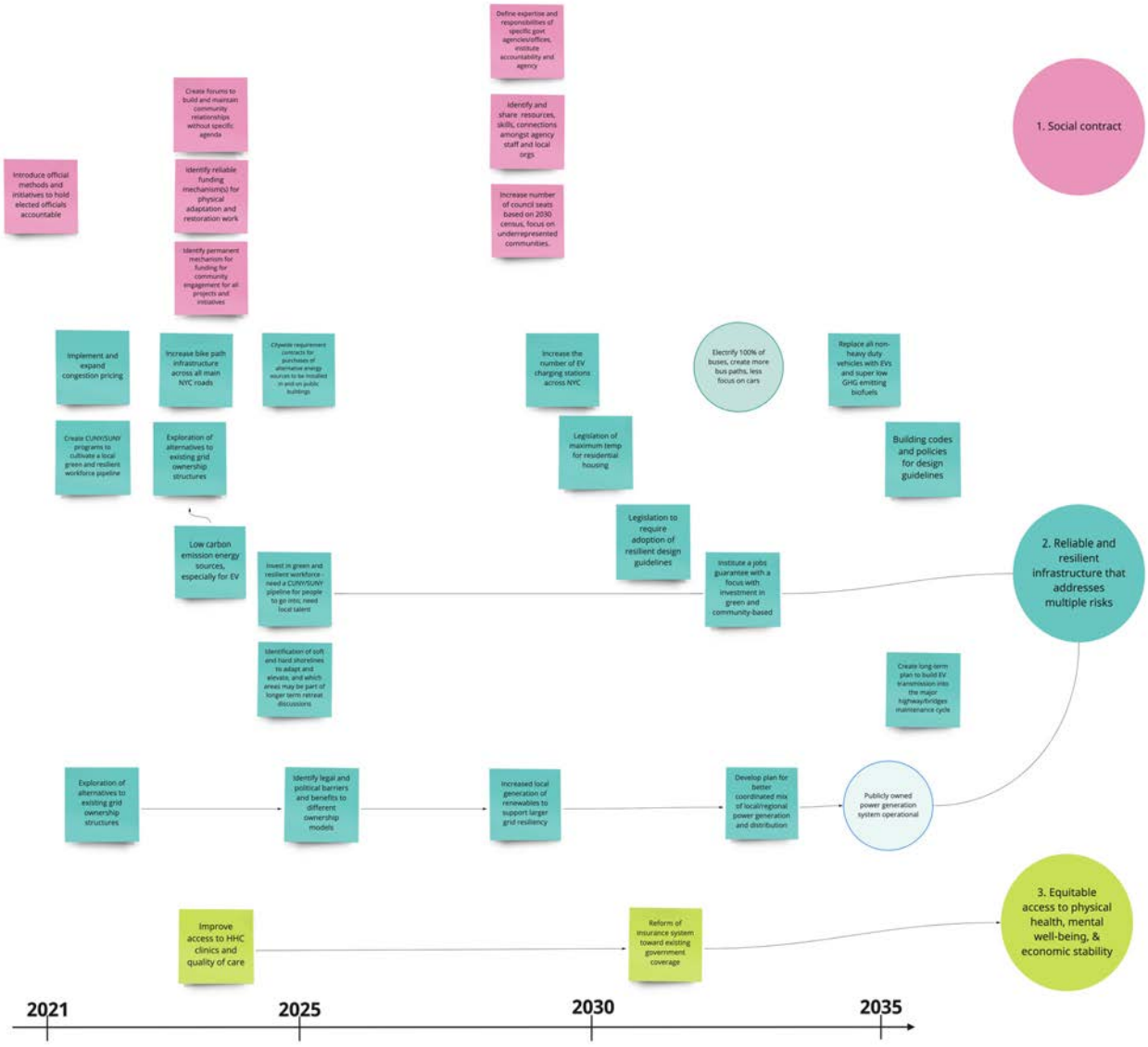


Figure 8. Near-term multi-hazard timeline co-developed by workshop participants

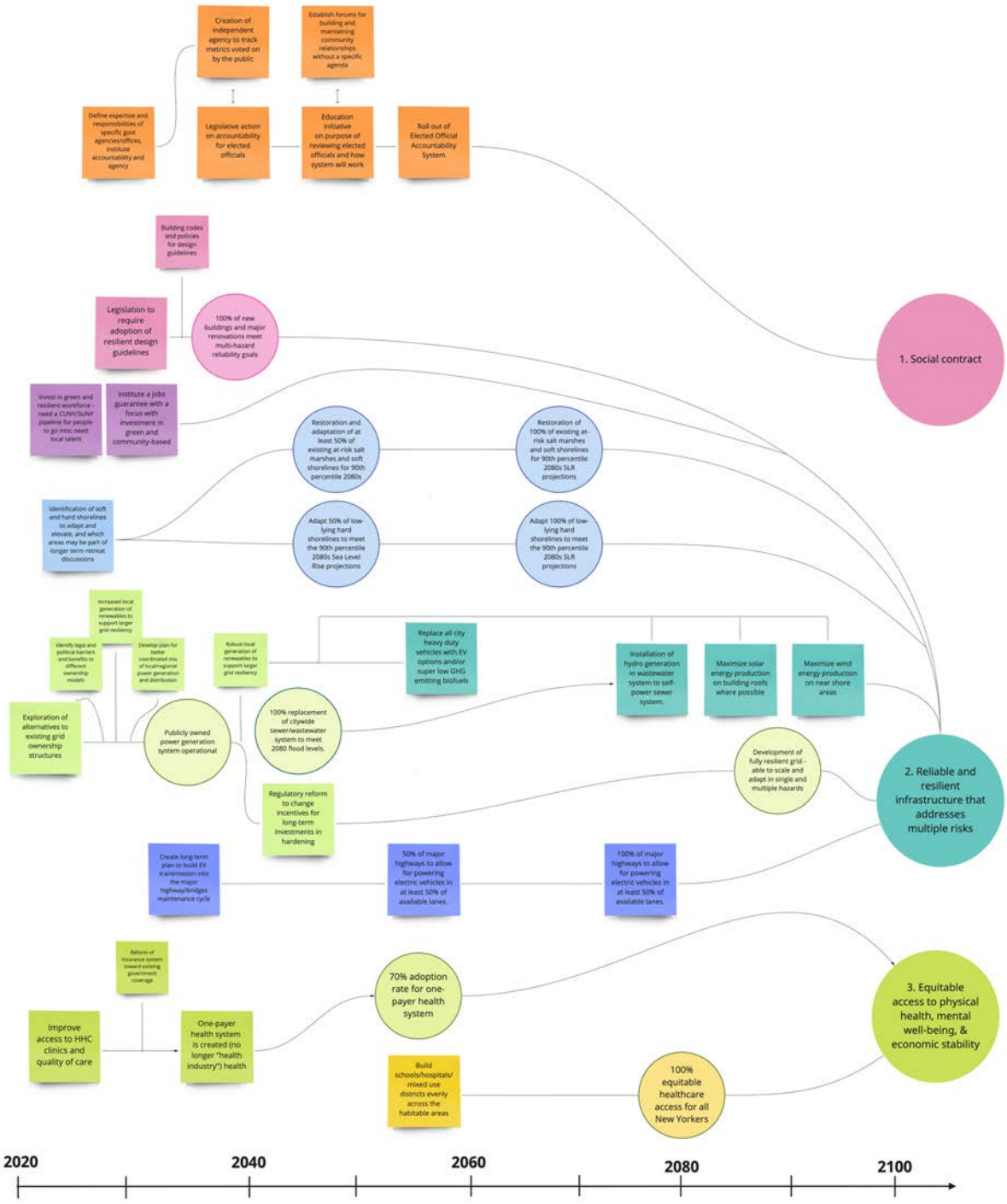


Figure 9. Long-term multi-hazard timeline co-developed by workshop participants

A day-in-the-life narrative: Multi-Hazard Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

Rita walks home from work, noting the darkening storm clouds rolling in at the edge of the skyline. She is just returning from a multi-agency meeting to prepare for the upcoming hurricane and heat wave projected to follow soon after. The establishment of the inter-agency resiliency group had come as a huge relief to Rita, who had been frustrated by challenges in communication and data sharing. Now, she can focus on better addressing upcoming climate threats and working with communities to create new resiliency measures like the community-owned solar project in her neighborhood. As the clouds accumulate overhead, Rita thinks about growing up in Sunset Park, where her family struggled to pay their monthly rent and were always fearful of eviction. Growing up, she dreamed of dedicating her life to her neighborhood, but never once considered working for city government. However, during her early 30's, the city piloted a community forum that connected New Yorkers with government workers to address inequitable access to physical and mental well-being and economic stability. After the forum eventually led to guaranteed single-payer healthcare and secure housing programs, she could imagine a role for herself as an intermediary between elected officials and her friends and neighbors.

Even more immediate, she could finally go to the doctor without having to worry if she could also afford to pay her utility bills. As she turns the corner to her apartment, Rita's neighbor George waves hello to her, pulling her back to the present.

George is pruning the trees outside his apartment before the big storm, and sees Rita turning the corner. After living most of his life feeling slightly distrustful of government, Rita has given him newfound faith at the age of 82. A few years before, she established a resiliency hub in the neighborhood that brought together people of all ages and backgrounds to work together to strengthen their neighborhood. George loves the opportunity to connect with his neighbors, especially after the death of his partner the year before, which had left him seeking community. Instead of sharing their hopes and challenges with little confidence of being heard or responded to, Rita communicated their concerns directly to the city and would share with them the ongoing work and challenges of city government. George snaps out of his daydream as Rita passes by, and waves in greeting. Rita asks George if he is excited for the post-storm block party, which partly because of the integrated resiliency design guidelines that protect the built infrastructure from heat and flooding, should happen only a few short days after the hurricane hits.

SCENARIO 2

Addressing coastal flooding and storms by 2100

New York City is projected to experience increases in both the frequency of one percent annual chance of coastal floods and in the height of these floods by 2100 (NPCC, 2015; NPCC, 2019). Over this timeframe, flooding will be exacerbated by sea level rise—likely two to four feet and potentially as much as 9.5 feet (Gornitz et al., 2019). By 2100, tidal flooding is expected to increase substantially in low-lying regions of NYC (Orton et al., 2019). In addition, projected increases in nuisance flooding in some communities and permanent inundation in others will lead to severe consequences for the health, well-being, and quality of life of many New Yorkers. A disproportionate economic burden is forecasted for the city's most vulnerable populations and, due to its deteriorating physical infrastructure, major repair and expansion projects will need support.

Ensuring that a future New York City is resilient to coastal flooding and storms requires **re-envisioning collaborative governance** based on a public-private-civic governance model to facilitate coordination across agencies and cross-sectorial decision-making. This future vision will **ensure residents are more resilient to future flooding** through a variety of mechanisms, including equitable opportunities for relocation, housing, and flood insurance. Finally, this future will focus on a systems approach to developing a **retrofitted city** that integrates natural elements of nature-based solutions with hard, engineered infrastructure.

Goal 1: Re-envisioning collaborative governance

- Develop governance for multi-functional infrastructure with co-benefits
- Mandate cross-agency and cross-sectoral decision-making and collaboration in public-private-civic model
- Identify cross-sectoral gaps to manage climate risk
- Establish cross-agency funding mechanisms at city and state level

Goal 2: Resilient residents

- Ensure equitable and affordable housing with protection from both inflated property values and large storm surges
- Buyout and relocation from flood vulnerable areas, accounting for diverse community needs and voices
- Invest in low income, historically marginalized communities to improve resilience and equity
- Create equitable flood insurance programs and mandate coverage

Goal 3: Retrofitted city

- Rely on nature-based solutions and engineering with nature
- Invest in retrofitting buildings to reduce waste and minimize flood risk
- Integrate natural carbon sequestration via green spaces and algae into architecture
- Create standards for waterfront elevation
- Revise regulations to encourage infill designed for ecological purposes
- Revise federal benefit-cost analyses to encourage nature-based solutions with multiple co-benefits, including social ones.

Coastal Flooding Descriptive Synthesis

Goal 1: Re-envisioning collaborative governance

This goal calls for a comprehensive and overarching approach to governance to address the interconnected and interrelated nature of coastal flooding, which affects the natural environment, human well-being, and built structures.

Participants envisioned a scenario where the challenges of coastal storms and flooding are approached collaboratively among agencies and across scales. With the aim of addressing multiple needs simultaneously, there will be a shared understanding among agencies and sectors of the challenges and solutions.

The primary focus is to build trust and break silos in order to establish strong relationships among agencies. The responsibility of resilience will be shared across city government, businesses, and citizens through a gradient of centralized and decentralized authority for decision-making. There will be a strong emphasis on accountability across both the public and the private sectors. Specific strategies and targets to achieve this goal include:

Collaborative governance

- Integrated decision-making with shared understanding and cross-departmental collaboration
- Cross-sectoral, multi-agency structure with integrated public-private-civic model
- Establish cross-agency funding mechanisms by 2030 at city level and by 2040 at state level
  - Empower agencies to work on multi-agency projects (and assign control) in the 2020's
  - Legislation (state and local) passed to enable cross-agency funding by 2025
  - Establish cross-agency funding mechanism at city level by 2030
  - Establish cross-agency funding mechanism at state level by 2035
  - Establish funding streams for discretionary use under auspices of collaboration by 2035
- Identify cross-sectoral and cross-agency capacity gaps to managing climate risk mitigation programs by 2025
- Identify staffing capacities and skills needed for climate risk mitigation programs

Public engagement

- Build an educated and engaged community by integrating an environmental design curriculum starting in middle school

Resilient infrastructure

- Focus on multi-functionality and co-benefits of new resilient infrastructure

Goal 2: Resilient residents

This goal ensures all city residents are resilient to flooding by ensuring access to affordable, equitable, and retrofitted homes safe from inundation.

The workshop participants envisioned that individual households and communities collectively and actively engage with public and private entities to design, build, and maintain a resilient city for all residents. There is an acknowledgement that rules, guidelines, and codes need to be versatile and multifunctional and that decisions need to consider diverse value systems. Where flooding or storms do occur, residents will be able to autonomously react and are financially and institutionally supported by the city if they opt to relocate or retrofit their homes. Specific strategies and targets to achieve this goal include:

Housing mobility

- Equitable and affordable housing with price protection
- All residents live in affordable homes that are safe from sea level rise and large storm events. There will be no basement residences
- Equitable flood insurance

Communities resilient to flooding

- Buy outs and relocation from flood vulnerable areas that account for diverse value systems, needs, and ability for self-determining relocation
- Investment in low income, disadvantaged communities to improve resilience and equity
- Enforcement of rules, guidelines, and codes on how to handle water on properties

Community engagement

- Active civic engagement
- Expand NYCHA Youth Program (2020) - Education for children in tune with future projections of flooding

Figure 10. Photograph, Bedford Stuyvesant Brooklyn. Kurtis Garbutt, Flickr.com

Goal 3: Retrofitted city

This goal focuses on reconstructed infrastructure to buffer NYC and its residents from most of the uncertainty and inequity accompanying projected coastal flooding and storms.

Through a social-ecological-technological systems approach, the city's design integrates ecological elements and nature-based solutions, together with human health and well-being goals, into the built environment. This 'engineered with nature' approach spans policy, operation, maintenance, research, and design. The primary objectives include flexible or agile buildings or structures that are safe-to-fail, are able to buffer storm surges, sequester carbon, and do not emit contaminants.

A retrofitted city is centered on solutions that provide co-benefits and are multifunctional. There will be a focus on natural solutions, where possible, over gray infrastructure, such as installing living shorelines instead of hardening shorelines. There will be revised codes to ensure implementation and enforcement. Specific strategies and targets to achieve this goal include:

Nature-based solutions

- Focus on systems approach with nature-based solutions and engineering with nature
- Adjust regulations to allow undeveloped areas (i.e., areas of future urban infill) to be preserved for ecological benefits and purposes
- Revise federal benefit-cost analyses (BCAs) to encourage nature-based solutions that provide multiple benefits

Building retrofits

- Design flexible, safe-to-fail buildings
  - Codes in place for retrofitted buildings by 2025
  - Agreement between citizens and government regarding new structures by 2030
  - Retrofitting buildings for less waste by 2030
  - Buildings are multi-use by 2035
- Integrate natural carbon sequestration into architecture (green spaces, water, algae)
- Create standards for waterfront edge elevations

Community decision-making

- Bolster resident engagement and communication in repurposing public space and infrastructure
  - Improve neighborhood and community decision-making by 2025
- Establish cross-sectoral metrics to evaluate proposed neighborhood solutions, such as environment (flora and fauna), health and well-being, safety, jobs, youth engagement, culture and community, violence prevention, water reuse, district energy potential, waste, etc.

Timeline: Resilience to Coastal Flooding

Timelines for addressing the Coastal Flooding and Storms adaptation and resilience goals: Workshop participants developed a detailed near-term (present day to 2035) and a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals.

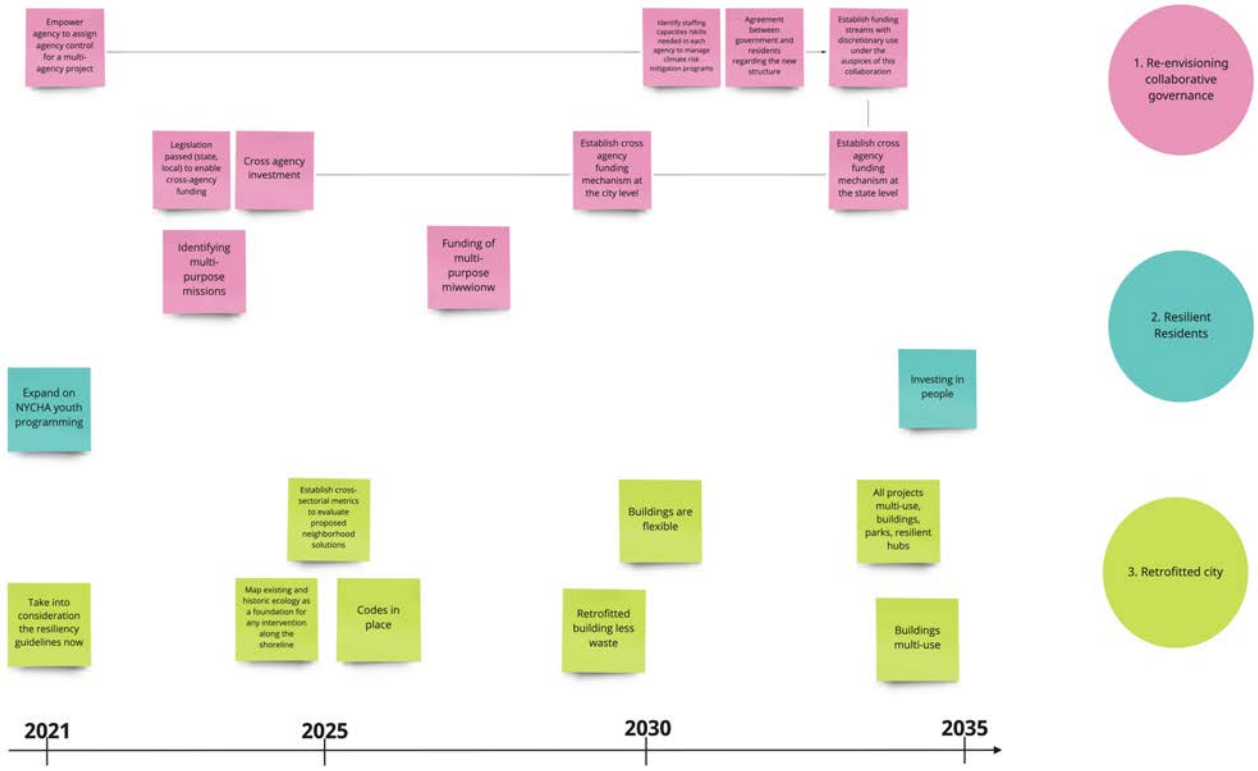


Figure 11. Near-term coastal flooding timeline co-developed by workshop participants

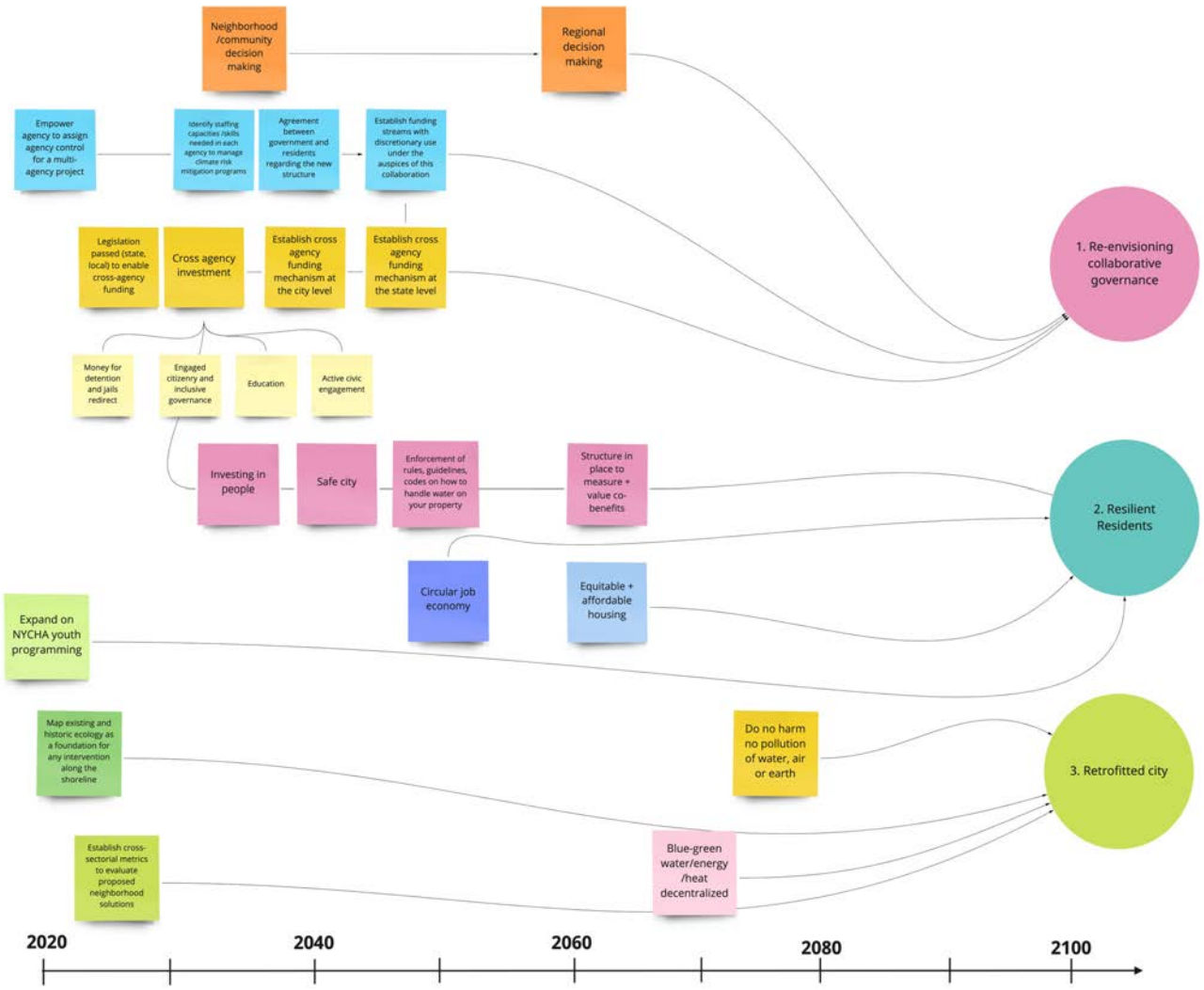


Figure 12. Long-term coastal flooding timeline co-developed by workshop participants

A day-in-the-life narrative: Coastal Flooding Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

It is 2100 and one of Maria's favorite events is coming up, getting to codesign and engage with fellow green space community stewards, multi-agency partners, and private sector collaborators on their neighborhood's living shoreline. On the agenda is the reintroduction of the Eastern cricket frog (Acris crepitans), updates on the human welfare index, and to share insights on how the retrofitting of multifamily housing in their neighborhood is progressing. She has been looking forward to the event, not only because she and her students thoroughly enjoy seeing the marshes recover and the natural environment flourish, but also using technology implemented by the city to help with participative governance activities.

Figure 13. Visualization of coastal flooding adaptation and resilience strategies in 2100, Designer: Eleanor Davol

Based on diverse value framings and knowledge systems, the technology shows residents the location, duration, and height of coastal inundation and what used to be referred to as 'nuisance flooding'. These minor events are absorbed by the structures put in place in 2050 by NYC's Multi-Agency Collaborative initiative.

Through an inclusive governance approach and engineered with nature, retrofitted and new infrastructure now buffers city residents, and the built and natural environment, from the now day-to-day rising and falling of water levels, simply called tides.

Everyone has access to technology that helps them make more informed decisions regarding their everyday activities as well as where to invest time, effort, and resources. The technology, updated in real-time, has been especially helpful to families and communities deciding to relocate or retrofit while the collaborative governance structures put in place in the 2030s have provided policy and guidance to support their decisions and ensure resilience and well-being for all.

The world-renowned funding mechanisms set up by the city's Multi Agency Collaborative initiative has continued to grow and one of its most celebrated accomplishments has been the significant increase in human welfare. All citizens are happy, healthy, and protected and resilience is the standard.

SCENARIO 3

Addressing rising temperatures and extreme heat by 2100

Annual heat waves in New York City are projected to increase in quantity and severity, leading to more cases of heat-related morbidity and mortality. Based on the highest projections for 2050, there are projected to be seven heat waves per year in New York City with an increase from 18 to 57 days above 90˚F by 2050, a more than three-fold increase (NPCC, 2013). In NYC, premature mortality resulting from heat waves is projected to grow between 47% and 95% by mid-century (Knowlton et al., 2007). A 2017 study projected that there may be as many as 3,331 annual heat-related deaths in New York City in the 2080s compared to 638 heat-related deaths annually between 2000 and 2006 (Petkova et al., 2017).

A future New York City that is resilient to rising temperatures and extreme heat would **eliminate heat-related illness and mortality** through a combination of infrastructure and health reforms. The future scenario will **rely on green vegetation and water features to mitigate heat**. It will also ensure excess heat waste (e.g., from air conditioning) is reduced or reused through heat recovery systems in order to minimize new energy use.

Goal 1: Eliminate heat-related illness and mortality

- Update construction codes to include shade requirements
- Mandate cooling breaks for workers
- Increase funding for community health programs
- Reform and expand LIHEAP
- Ensure universal access to sustainable cooling
- Ensure quality, single-payer healthcare

Goal 2: Minimize and reuse waste heat sources and maximize the city's green and blue infrastructure (vegetation and water features)

- Require low-energy building design
- Reduce use of absorptive building materials
- Incorporate heat recovery systems
- Integrate water features for evaporative cooling
- Electrify truck fleets and reduce truck traffic
- Expand access to public transit
- Repurpose private street parking
- Integrate green infrastructure and cool corridors

Rising Temperature and Extreme Heat Descriptive Synthesis

Goal 1: Eliminate heat-related illness and mortality

In this goal, all New Yorkers will have both the capability and information needed to respond to extreme heat events.

There will be access to quality healthcare for all New Yorkers, laws that require mandatory cooling breaks and limited hours for outdoor work in excessive heat, expansions to LIHEAP to provide assistance with energy costs, and adequate funding for community health programs. These programs will help eliminate health disparities across communities. Specific strategies and targets to achieve this goal include:

Heat stress reduction regulations and governance mechanisms for cooling

- Update codes to include shade requirements in new construction
  - 50% of open space is shaded
- Mandatory cooling breaks and limited hours for outdoor, active workers in excessive heat. Required micro-cooling centers and break rooms. Make OSHA standards that relate to heat.
- Better coordination and communication across city agencies in response to heat-related emergencies
  - Updated directory for agency coordination
  - Internal working group across departments with monthly meetings to organize planning and response

Community resources for cooling

- Increase budget to fund community health programs by 2025
  - Fund community health programs to decrease health disparities that make communities more vulnerable to extreme heat by 2030
- Reform/expand LIHEAP
- Universal access to sustainable cooling
- Universal access to quality, single-payer healthcare
- Educational component on the impact of heat on surface transportation

Goal 2: Minimize waste heat and maximize green and blue infrastructure (vegetation and water)

This goal focuses on minimizing additional heat sources in the city, as well as increasing the infrastructure that helps to mitigate heat.

The workshop participants envisioned New York City will have significantly reduced waste heat sources, and the remaining waste heat will be reused to generate new energy. The city will also maximize the use and implementation of green and blue infrastructure with vegetation and water features. This will be achieved through updates to the building code in order to, for example, require the use of passive or low-energy building design, reduce the use of absorptive materials, and require green roof installation retrofits.

Building-energy infrastructure

- Require use of passive house/low-energy building design
  - Update building codes to require low-energy design and meet indoor air quality standards
- Retrofit and build with heat recovery systems
  - 100% of buildings are heat sinks by 2085
- Update building codes to reduce the use of absorptive materials
  - Building code scoring for building heat footprint
  - Update building codes to require low-energy design and meet indoor air quality standards by 2050
  - Incentivize retrofits
- Require green roof installation retrofits
  - 90% of roof space is green or solar by 2060

Green and blue infrastructure

- Water features for evaporative cooling, such as misters or ponds
  - 15% of neighborhood space includes water features
  - Reclaim curb space for green infrastructure, including tree canopy
- Green infrastructure (right of way) and cool corridors
  - Increase green space and natural infrastructure including green facades by 50%

Transportation infrastructure

- Invest in freight and maritime infrastructure in order to reduce truck traffic in the city. Remaining trucks and cars are electric vehicles
  - 80% reduction in truck traffic
- Ensure that all New Yorkers are well-served by green and efficient public transit
- Expanded access to people-based, better networked public transit
- Car-free zones
- Bike infrastructure prioritized over private cars with >50% travel lanes for bikes
- More subways, Bus Rapid Transit, and better network
- No private street parking and no parking minimums
  - 50% of street parking spaces are repurposed by 2030
- Enforcement of safety and traffic laws including expanding to automated enforcement by 2023

Timeline: Resilience to Extreme Heat

Timelines for addressing the Extreme Heat and Rising Temperatures adaptation and resilience goals: Workshop participants developed a detailed near-term (present day to 2035) and a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals.

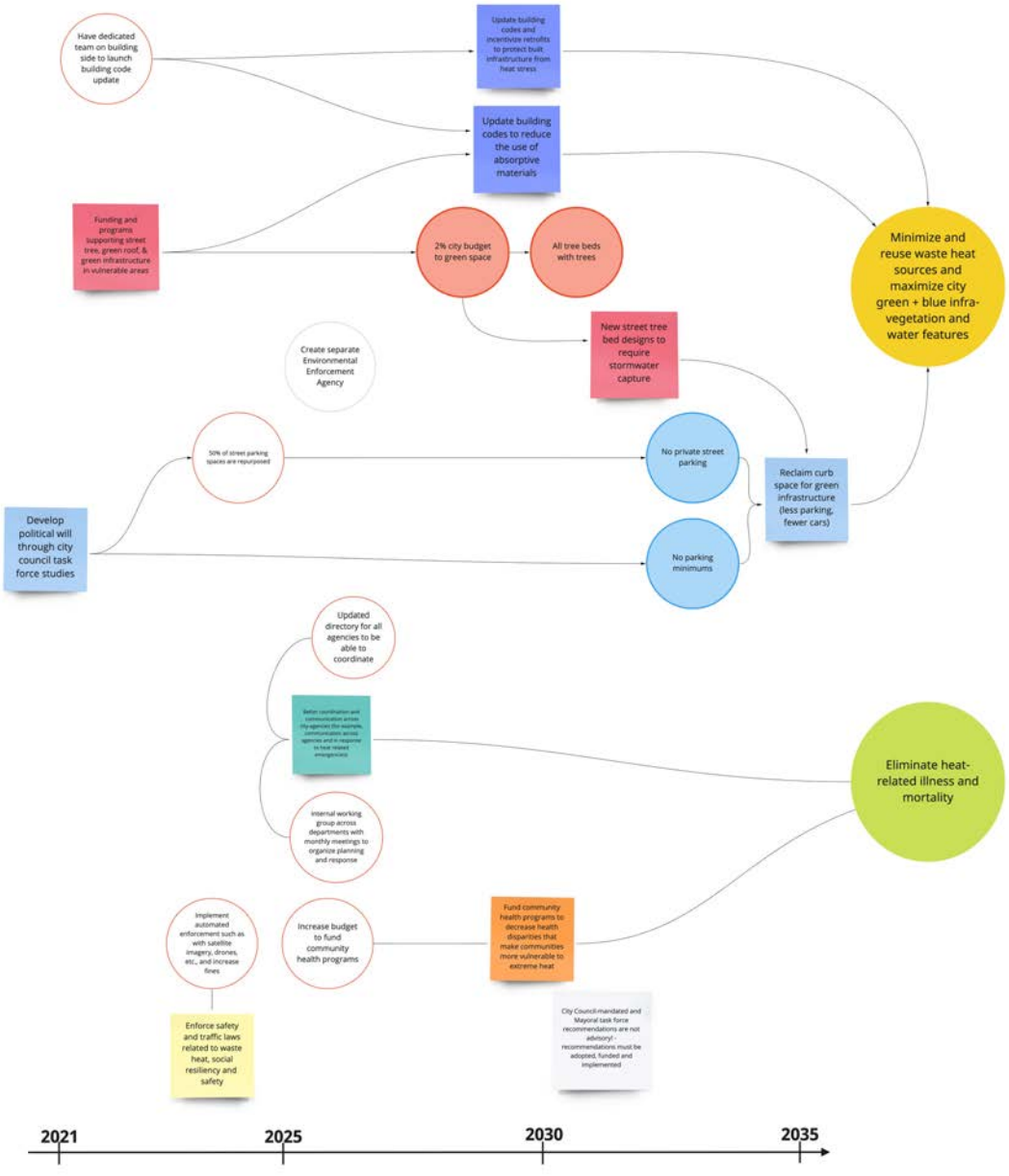


Figure 14. Near-term extreme heat timeline co-developed by workshop participants

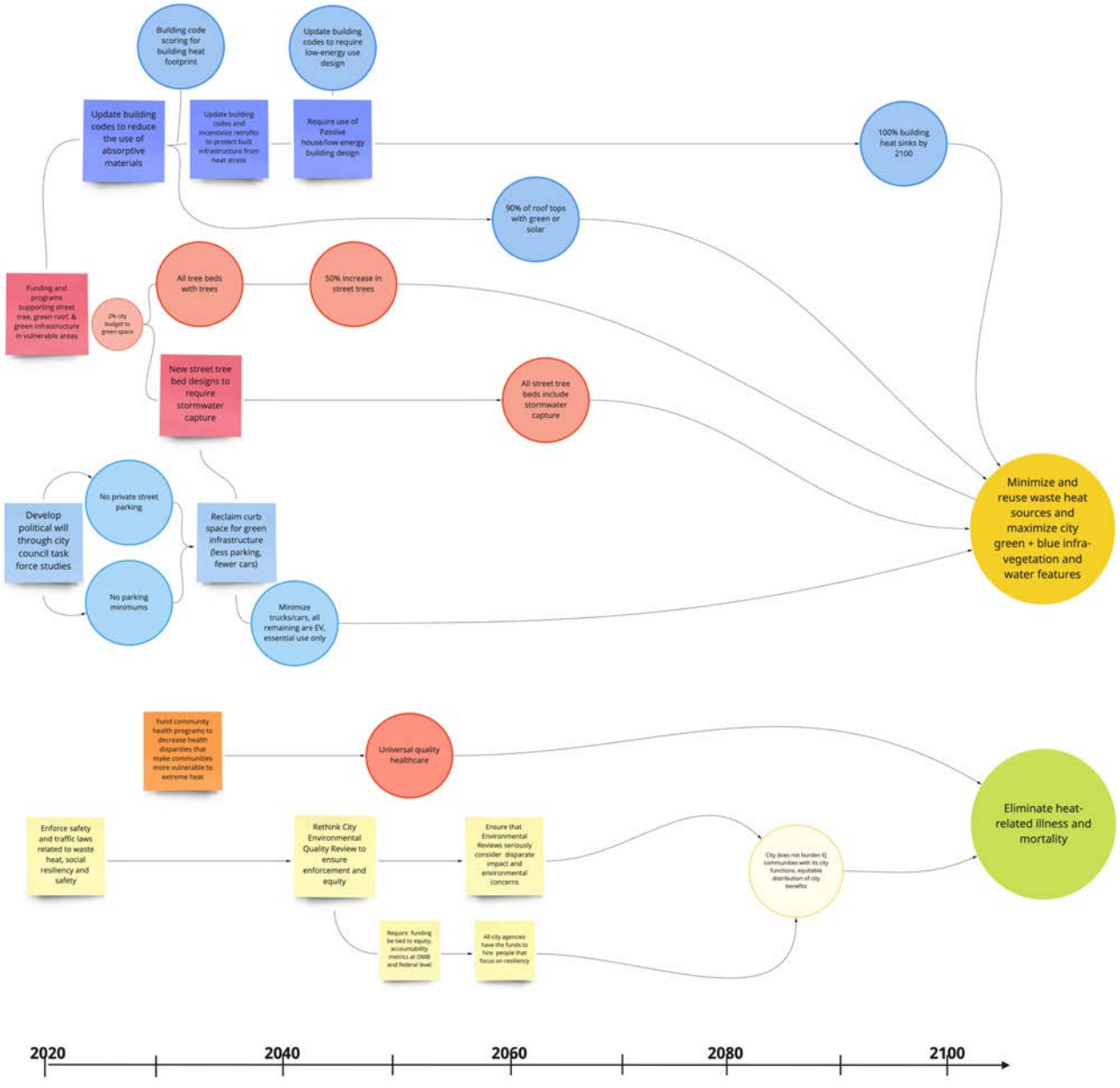


Figure 15. Long-term extreme heat timeline co-developed by workshop participants

A day-in-the-life narrative: Extreme Heat Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

A four-day extreme heat wave is coming, but Alex isn't worried. A combination of trees, building shading, and subsidized AC utility costs had finally made his apartment bearable during the hottest days of summer. His neighborhood, Bushwick, now more closely resembled what in the early 1600s the Dutch had named Boswijck, or "neighborhood in the woods". Because of cool corridors that provided shade in the summer, his aunt, who had a heart condition that put her at risk when exposed to extreme heat, could still walk outside on hotter days instead of always staying inside.

Passive cooling and the slow process of acclimatization over the years had also reduced the need for AC across the city. Alex was glad that he no longer had to be constantly stuck in traffic or pay for parking, since the enactment of a car free zone and the establishment of a well-networked public transportation system.

Figure 16. Visualization of extreme heat adaptation and resilience strategies in 2100, Designer: Eleanor Davol

Growing up, Alex recalled his dad complaining during the summer months about his grueling construction job that had him working all day in the heat with little respite. Now, in the same profession as his father, Alex welcomed the mandated cooling breaks and the chance to go home early on extremely hot days where he could spend time with his family. He felt like the breaks actually made him work more carefully and made everyone on the site a little friendlier.

SCENARIO 4

Addressing winter extremes (cold snaps and winter warms) by 2100

Although extreme cold events are predicted to decrease over the course of the next century, a number of associated risks remain or are expected to be exacerbated by this change. First, concerns about community vulnerability, public well-being, and physical infrastructure will continue during the remaining cold snaps. In fact, existing vulnerabilities will likely become heightened as high-risk events become less common; cold weather planning and infrastructure will still remain critical, but may need more concerted effort to stay salient. Second, an increase in winter warms and more frequent fluctuation between hot and cold temperatures will likely have myriad effects on building heat systems, transportation infrastructure, biodiversity, and more. As the climate continues to warm, the frequency of extreme cold days is projected to decrease over 33 percent by the 2050s and ~50 percent by the 2080s while polar vortex events may be on the rise (González et al., 2019; NPCC, 2015).

A future New York City that is resilient to winter extremes would **minimize community vulnerability and improve preparedness**. The future will rely on **investing in zero-carbon infrastructure** that can withstand freeze-thaw cycles. There will be a focus on clean and reliable heating sources to reduce disruptions and increase resiliency during winter extremes. Finally, the future will also **maximize public well-being and mental health, ensuring residents are prepared for winter weather** and can enjoy its benefits.

Goal 1: Minimize community vulnerability and improve preparedness

- Create localized early warning system and consistent public messaging
- Foster mentality to enjoy winter weather and accept restrictions
- Increase tele-work and tele-health options
- Increase community-level education
- Build out citizen science initiatives
- Expand social safety programs
- Allow access for anyone who qualifies or applies for LIHEAP
- Mandate that housing is available for all, and that housing is a right
- Implement emergency shelters

Goal 2: Invest in strong, zero-carbon infrastructure that is resilient to winter extremes

- Transform water, energy, and transit infrastructure to withstand freeze-thaw cycles
- Invest in clean, reliable fuel sources and electric heating Implement heated sidewalks and roadways
- Promote building retrofits for energy efficiency
- Put more electric lines underground
- Reduce disruptions and emergency response

Goal 3: Maximize well-being and mental health during winter colds/storms

- Ensure public transportation and bike lanes are fully functional year-round
- Treat bike lanes equal to roads
- Improve wheelchair and other accessibility
- Construct pedestrian covered/heated bridges or tunnels
- Move snow to designated park areas
- Expand community involvement in citizen science initiatives

Winter Extremes Descriptive Synthesis

Goal 1: Minimize community vulnerability and improved preparedness

This goal will address communities vulnerable to cold weather by focusing on public health, housing, and community preparedness.

Improving services and housing for vulnerable communities during extreme cold snaps by addressing homelessness and access to heating infrastructure (such as through rapid deployment of emergency shelters) will be foundational steps. The development of better communication and education about winter extremes will also be key, such as by expanding winter preparedness education and public warning systems, informing households about aid options (e.g., LIHEAP, Strengthening Communities through Recovery, etc.), and advocating for telework options where possible. An additional public health priority will be ensuring that sidewalks, bike paths, and other pathways are rapidly accessible after snow/ice events. Specific strategies and targets to achieve this goal include:

Guaranteed housing

- Zero homelessness
- Housing available for all, housing as a right
- 100% access to heating/cooling

Access to health and social services

- Increased tele-work and tele-health options for flexibility during winter weather
- Anyone who qualifies or applies for LIHEAP will be given access
- High mobility safety
- Ensuring community health with a focus on hypothermia or other illnesses, including no carbon monoxide poisoning resulting from heating or gas use in homes
- Rapid implementation of emergency shelter during storm or cold snap events

Anticipatory planning, preparedness, and response

- Consistent and robust public messaging and public warning systems regarding winter weather
- Early warning system (localized to neighborhoods) that encourages limited transit during events
- New mentality to enjoy winter weather and accept restrictions
- Focus on preventive planning and maintenance
- Increased community-level educational programming and outreach on winter preparedness, building out citizen science initiatives
- Expand Be a Buddy for winter weather emergencies
- Expand Strengthening Communities through Recovery program

Goal 2: Minimize waste heat and maximize green and blue infrastructure (vegetation and water)

This goal focuses on zero-carbon infrastructure that is resilient to winter extreme events in order to have no disruptions, reduce emergency response, and improve the built environment.

A three-pronged approach will be used to meet this zero-carbon infrastructure goal. First, a broad range of infrastructure will be built to withstand the increasing frequency of freeze-thaw cycles. Second, all infrastructure will meet decarbonization standards, including by utilizing fossil fuel-free energy sources, electrifying equipment, and overall regulating retrofits. Finally, all infrastructure will also meet design standards that limit ecosystem harm – in particular by phasing out the use of salt on icy sidewalks and roads. Specific strategies and targets to achieve this goal include:

Resilient and sustainable infrastructure

- Transform water, energy, and roadway and public transit infrastructure to withstand freeze-thaw cycles
- Incentivize and regulate building retrofits to improve energy efficiency and insulation
- More underground electric lines
- Passive strategies for heated sidewalks and roadways to accelerate ice and snow melt and stop salting

Zero-carbon infrastructure

- Invest in clean, reliable fuel sources to keep heating equipment functional
- Invest in extensive electric in-home heating
- 100% electric in-home heating by 2050

Goal 3: Maximize well-being & mental health during winter cold and storm events

After addressing vulnerable communities and infrastructure during cold weather events in the other goals, this goal focuses on prioritizing general well-being and mental health by promoting cold weather positivity and ensuring access to outdoor spaces.

This goal envisions a culture of cold weather positivity. For example, there will be a focus on maintaining accessibility to public spaces for all community members. Additionally, there will be new cold weather pedestrian options, such as covered bridges or underground tunnels for pedestrians. Finally, there will be more winter events and activities and a focus on creating outdoor recreation by intentionally shoveling snow to park areas to be used as recreation. Specific strategies and targets to achieve this goal include:

Improved outdoor access and mobility during winter snow events

- Ensure public transportation and bike lanes are fully functional year-round. Bikes treated equally to roads
- Improve wheelchair and other accessibility for people with disabilities and for the elderly
- Pedestrian covered and heated bridges and underground pedestrian tunnels to encourage people to leave their homes
- Move snow to designated park areas so not an obstruction—instead used for recreation
- Community involvement in communication and community science initiatives

Timeline: Resilience to Winter Extremes

Timelines for addressing the Winter Extremes adaptation and resilience goals: Workshop participants developed a detailed near-term (present day to 2035) and a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals.

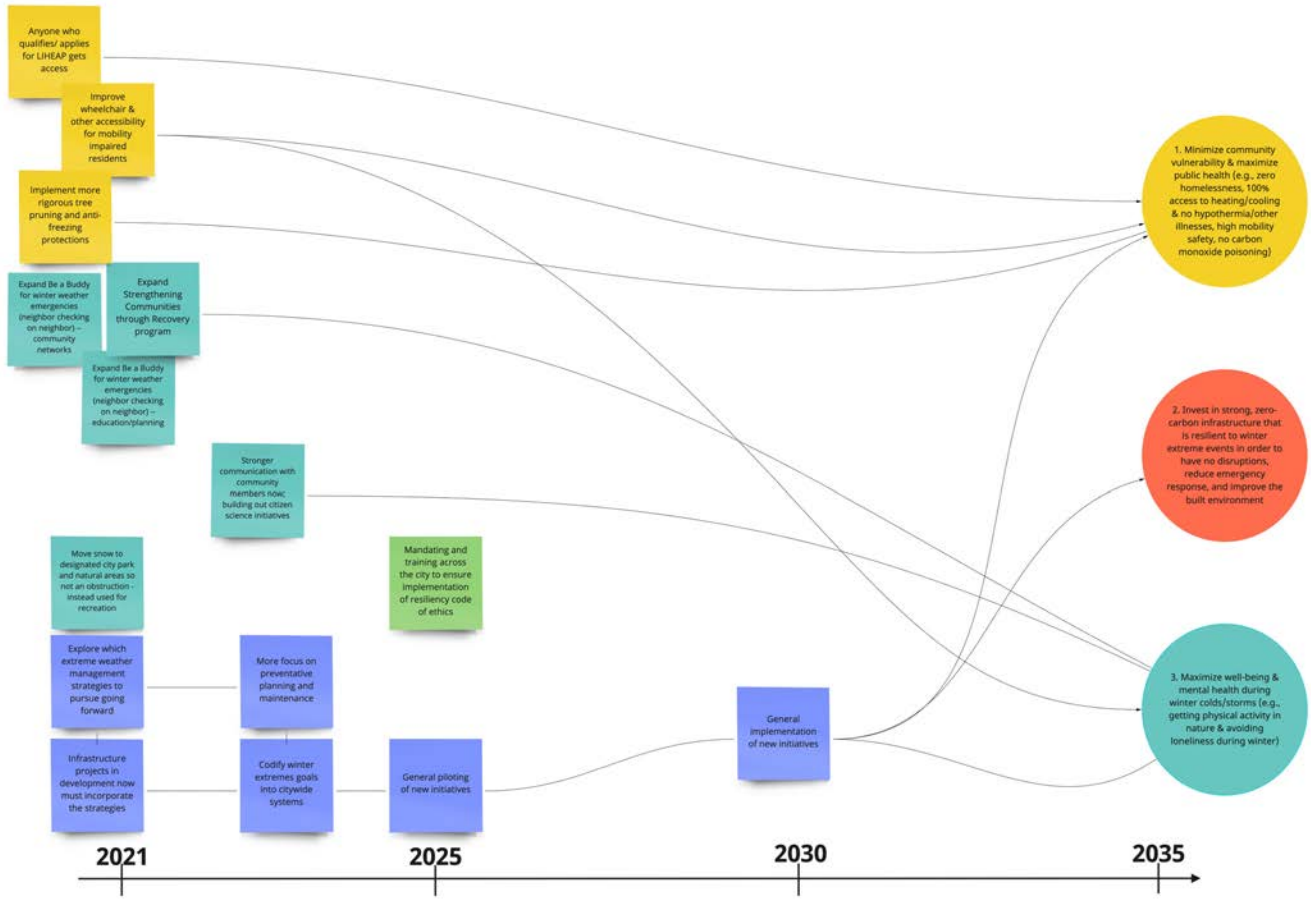


Figure 17. Near-term winter extremes timeline co-developed by workshop participants

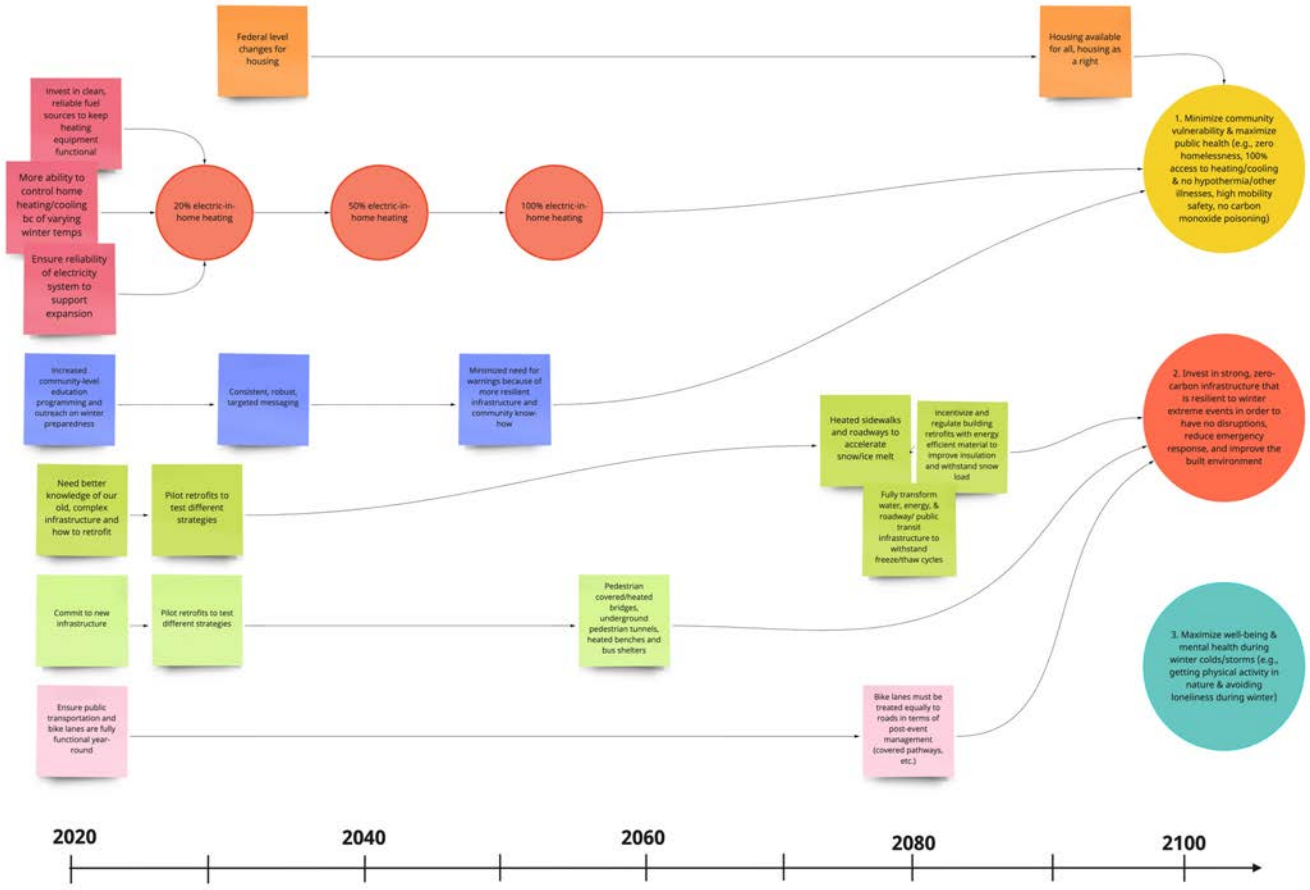


Figure 18. Long-term winter extremes timeline co-developed by workshop participants

A day-in-the-life narrative: Winter Extremes Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

It is the morning after the snow storm, and Carmen is getting ready to go outside on her own. Her older sister Lindsey had left the house early to check in on their neighbor after the blizzard as part of the Be a Buddy Winter program. Even though new insulation made the houses much warmer and energy infrastructure was built to withstand the increasingly common freeze and thaw cycles during the winter to keep apartments lit and heated, Lindsey liked to check in. Carmen zipped up her coat and headed out into the streets of what was formerly called Staten Island. She remembers learning in school how the indigenous Lenape had called it *Eghquhous*, which means "the bad woods". Despite development over the years, some of these "bad" woods had been retained, and the tree branches hung heavy with snow. Her path is clear as she walks, thanks to heated sidewalks that kick in during emergencies. She watches the rivulets of water from melting snow streaming into the storm drains while she carries on to her destination, the park. When she arrives at the park, she sees her friends playing atop a huge mountain of snow that had been created earlier that morning by the DSNY plows, and runs toward them.

A few days later, when a warm front comes in that rapidly melts the snow, the recreation of natural wetlands and improved stormwater drainage primarily implemented to address extreme rainfall becomes paramount. Instead of overwhelming the stormwater system, the snowmelt makes its way back to the wetlands and the biodiversity it supports, like the black willow trees, jewelweed, and shellfish.

Figure 19. Winter extremes scenario visualization, Artist: Ann Armstrong

SCENARIO 5

Addressing extreme precipitation and flooding by 2100

Annual precipitation, as well as flash flood events due to heavy rainfall, in New York City is projected to increase between 4 and 11 percent by the 2050s, and between 5 and 13 percent by the 2080s (González et al., 2019; NPCC, 2015). Because New York has a high percentage of impervious surfaces, which do not allow for natural infiltration of water and can increase runoff during rain events, and an under-capacitated sewer system, the social, environmental, and infrastructural impacts from extreme precipitation are exacerbated.

In response to these challenges, a future NYC that is resilient to extreme precipitation will ensure the city embraces living with water and **residents have agency in decision making to enhance individual and community resilience**.

A future New York City that is resilient to extreme precipitation would **embrace living with water through integrated watershed management and combined natural-green and hard-engineered infrastructure** to convey water in times of heavy rainfall. New Yorkers would have the information, infrastructure, and ability to be both mobile and stable in the case of an extreme rain event. In particular, there would be prioritized and expanded affordable housing in low flood risk areas.

Goal 1: All New Yorkers have agency and choice in mobility & stability

- Expand affordable and temporary housing supply in low flood risk areas
- Improve risk communication and education
- Invest in networks of community stewards
- Develop shelter in place and emergency methods for getting to higher ground
- Prioritize infrastructure investments based on vulnerability
- Expand access to flood insurance
- Expand stock of resilient buildings
- Establish land trusts

Goal 2: Embrace living with water

- Design semi-naturalized streetscapes, reutilizing transport spaces for water conveyance
- Implement natural systems to reduce stormwater runoff across city
- Update sewer and stormwater systems
- Rely on best practices for fast stormwater drainage to prevent disease risk
- Integrate cloudburst management practices
- Integrated watershed management
- Daylight streams

Extreme Precipitation Descriptive Synthesis

Goal 1: All New Yorkers have agency and choice in mobility & stability

In this goal, all New Yorkers will have both the information and capability to respond to extreme precipitation risks in part by ensuring everyone has adequate healthcare, decent education, a living wage, and quality and safe housing.

Through a combination of better predictive modeling for risk assessment and expanded risk communication, information, resources, and capacity, residents will have stronger confidence in the predictions. They will also have the agency and information they need to make the safest and informed decisions for their household in the event of flooding from extreme rain events. At the same time, residents will have stability through secure access to safe transportation and housing. The residents will also have mobility with the ability to relocate when needed. Specific strategies and targets to achieve this future vision include:

Housing mobility

- Expand affordable housing supply in lower risk areas and develop more resilient building stock, including ensuring underground spaces are retrofitted for safety
- Build capacity to temporarily house people

Risk communication, education, and data informed decision-making

- Educate public on how to assess individual flood risks
- Improve risk information flows around general precipitation risk, including on disease risks associated with more surface water
- Improve predictive modeling for better ability to assess risk & plan amidst uncertainty

Community resilience and services

- Shelter in place options and emergency methods for getting to higher ground for all (at work, in transit, at home)
- Base the prioritization of infrastructure investments on vulnerability
- Expand access to flood insurance / recovery resources to areas outside of coastal flood zones, but vulnerable to extreme precipitation, and / or multi-hazards
    - Include default flood insurance from any type of flooding in all policies for property owners and renters
- Invest in and fund network of community land stewards of green spaces leading to the eventual establishment of land trusts

Goal 2: Embrace living with water

In this goal, the focus is on managing stormwater efficiently through integrated ecosystem-based and engineered solutions.

Urban neighborhoods will be connected with natural systems and semi-naturalized streetscapes to recreate a natural watershed for stormwater conveyance and recreation. A network of compensated green stewards would help to manage these landscapes, eventually leading to the establishment of land trusts. With fewer cars on the road, transportation spaces like highways and tunnels could be repurposed for water conveyance. Coupled with strategies to address drought, stormwater runoff could be captured and reused for other purposes. Specific strategies and targets to achieve this goal include:

Integrated natural-green and hard-engineered infrastructure

- Mimic biological processes alongside built environment and connect large, naturalized systems to urban neighborhoods to recreate a natural watershed for conveyance and recreation
  - Semi-natural streetscape design, such that transport spaces of highway systems and tunnels can be reutilized for water conveyance during flood events
  - Repurpose high risk areas into productive uses, such as natural ecosystems, parks/recreation, etc.
  - Build larger scale stormwater capture or detention to complement green infrastructure
  - Implement natural conveyance system for moving water quickly
    - 100% conversion of impervious to pervious surfaces
- Integrate cloudburst management practices
- Daylight streams
- Look at best practices from other cities to speed up drainage for preventing disease risk associated with surface water

Integrated stormwater management

- Use natural systems to reduce stormwater runoff in all parts of the city not just inundated areas
- Separate combined sewer systems
- Integrated watershed management
  - One Water strategies related to drought and coastal flooding, such as decentralized systems for drought
  - All properties capture the runoff that they produce, reducing flow by 30% into sewer systems by 2040, 100% reuse of captured stormwater for other purposes by 2050 (potable and non-potable)

Figure 20. New York City Extreme Flooding Scenario .(NYC Stormwater Resiliency Plan). Screenshot from www.stormwater.nyc

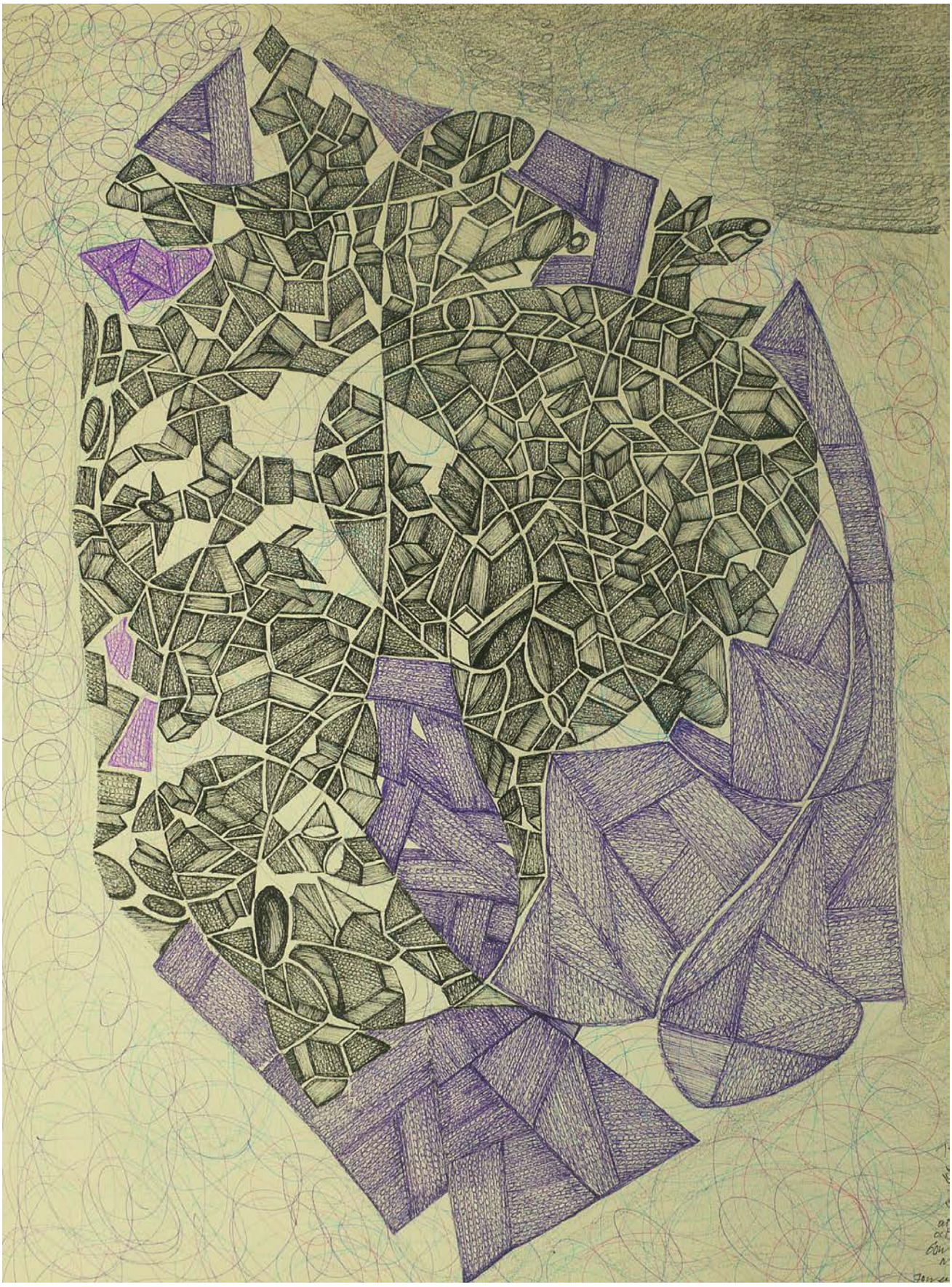


Figure 21. Extreme precipitation scenario visualization, Artist: Edi Friedlander

Timeline: Resilience to Extreme Precipitation

Timeline for addressing the Extreme Precipitation and Flooding adaptation and resilience goals: Workshop participants developed a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals. Participants in the Extreme Precipitation group did not focus on a near-term timeline because many near-term strategies had recently been laid out in the New Normal and Stormwater Resiliency government plans.

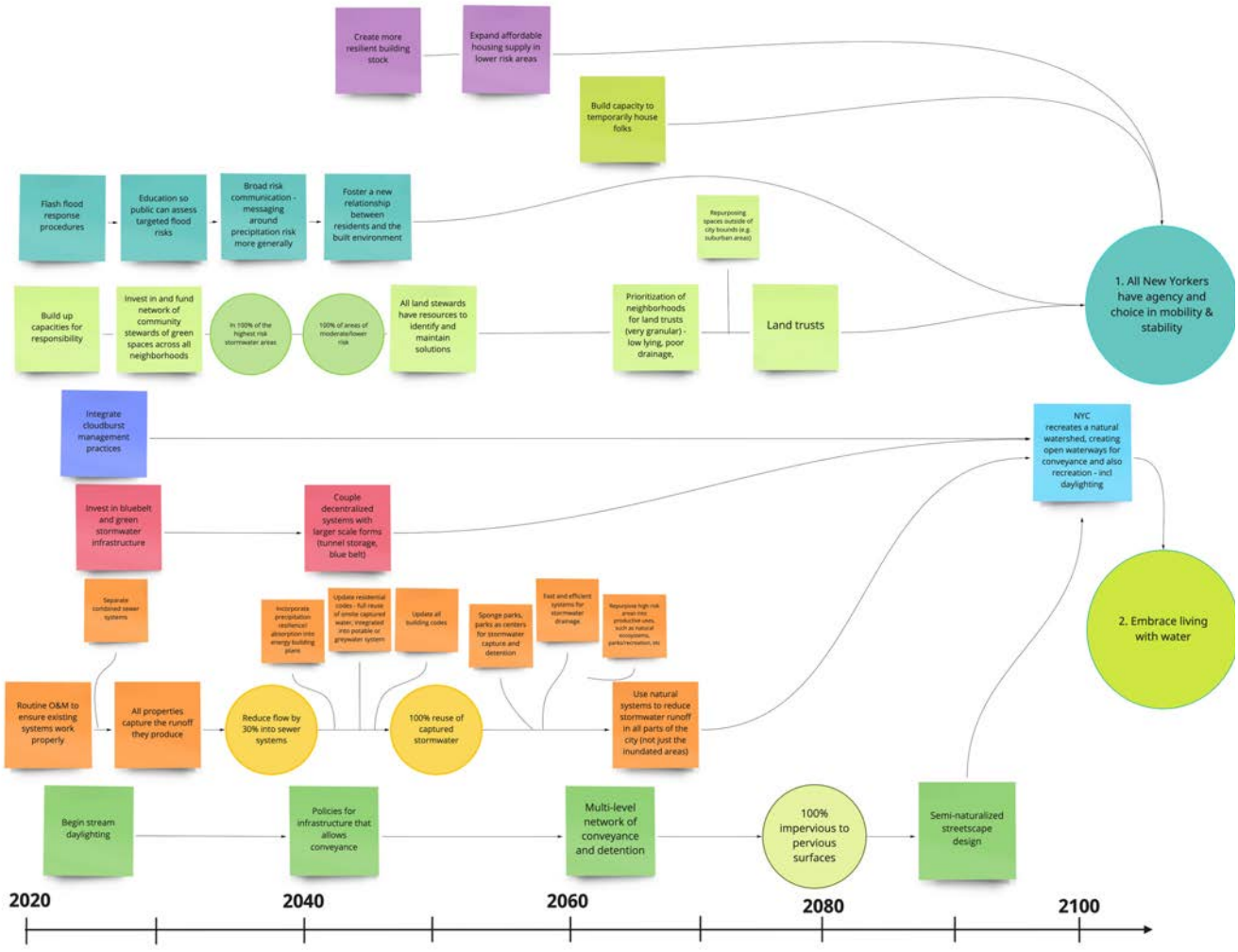


Figure 22. Long-term extreme precipitation timeline co-developed by workshop participants

A day-in-the-life narrative: Extreme Precipitation Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

It is the year 2100 and the day of a heavy rain event that in earlier decades would have shut down roads and flooded apartments throughout the City. Maria reflects on the stories her great-grandmother used to tell her about the ever-present fear that her family's basement apartment in an area that was then called Southeast Queens would flood or the times she would pick up her mom from school late, soggy and miserable, after having to wade through knee-deep water to get to the subway. Today, Maria does not live in fear of these floods. Two days before the rainstorm, she received a city-wide notification in Chinese and English that a heavy rain event was coming and resources and tips to prepare for a potential flash flood.

Figure 23. Visualization of extreme precipitation adaptation and resilience strategies in 2100, Designer: Eleanor Davol

Although she feels safe because she has a secure, flood-resistant apartment, she can now make arrangements to avoid unnecessary travel during the peak hours of the storm. The day before the storm, she receives a text from her neighborhood community coordinator who checks to make sure she's aware and prepared. The coordinator encourages her to check in on her neighbors, if safe, during and after the heavy rain event.

The day of the storm, Maria takes the electric bus to her job and quickly checks the City's real-time flood tracker to see a slow trickle of images of flooded streets taken by residents in other parts of the city. She arrives at the school where she teaches and is grateful for the permeable playground and the subsurface detention system that was recently expanded. All jobs now prioritize the concept of regeneration, so her lesson plans revolve around ensuring that her students are contributing back to the ecosystem and to people. Today, she will use the storm as an opportunity to share the history of how New York adapted its infrastructure to connect with the natural regional watershed system to better prepare for these types of flooding events. Because of the connected wetlands and minimal impervious surfaces, there is little fear of flooding. While she is teaching, the rain starts to come down. Nearby, surrounding highways and tunnels are being closed off to traffic and activated for water conveyance, relieving pressure on the sewer systems and local roads, which are now all separated to prevent sewage from contaminating the waterways. After finishing her lesson, she messages her group of green space community stewards for an update on the conditions in their neighborhood.

After hearing that all is clear, she and her students receive a real-time update that one block near where several students live is flooded due to an unexpected failure. The faculty initiate a shelter-in-place program where those students can stay until the flood has subsided. The problem is fixed quickly thanks to earlier preparedness measures, and Maria travels back home.

SCENARIO 6

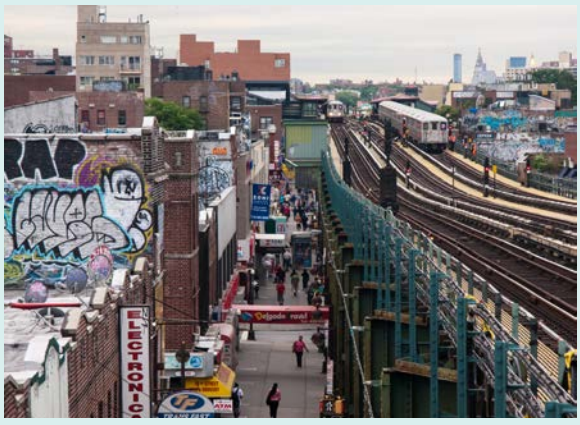
Drought and shifting water demand

Droughts are expected to become more frequent and over longer extended periods. By 2050, the severity of widespread summer drought in New York is projected to more than double and will be five times greater by 2080. There is a likelihood of persistent drought lasting longer than five years in the future (González et al., 2019), which could impact the City's water supply. In addition, future drought will lead to increased salinity in the estuary with ecological impacts throughout the watershed and the coastal ecosystem, as well as potential corrosion of infrastructure.

A future New York City that is resilient to drought and shifting water demand would use a **regional approach to maintain freshwater supply**, ensure that all New Yorkers have **equitable access to clean water,** and **minimize potable water waste** to protect water quality and quantity.

Goal 1: Maintain freshwater supply for local and regional ecosystems including people

- Create regional water supply and demand plan
- Establish community engagement specialists
- Increase educational programming on drought vulnerability
- Install automated water leak monitoring
- Create (dis)incentives to reduce water imports from other regions



Goal 2: 100% equitable access to water

- Establish water pricing based on tier use and income
- Ensure access to potable and freshwater for all

Goal 3: Landscapes are conserved and managed to be resilient and protect water

- Increase drought tolerant vegetation
- Expand availability of water conservation and reuse measures
- Increase permeable pavement
- Create systems for stormwater capture
- Develop health regulations on gray water
- Develop infrastructure to collect, store, and move rainwater
- Establish incentives for low water use appliances

Photograph, Roosevelt Avenue, Jackson Heights. Doug Turetsky Flickr.com

Drought and Shifting Water Demand Descriptive Synthesis

Goal 1: Maintain freshwater supply for local and regional ecosystems and people

This goal focuses on developing an integrative knowledge system for local to regional water governance to ensure future water security.

The future will prioritize an integrated knowledge system for water governance and security. It will include initiatives to develop capacities for long-term, multi-scale planning and policy development, community engagement, environmental education programing, and technology infrastructure. Specific strategies and targets to achieve this goal include:

Water governance

- Regional water supply and demand plan (updated every five years)
- Incentives/disincentives to reduce water imports from other regions

Drought infrastructure

- Automated, smart water leak detection

Community drought resilience

- Resiliency hubs with regular participation and contributions from government and non-government groups
- Establish engagement specialists for each community district who focus on strengthening climate knowledge
- Increase educational programming on drought vulnerability

Goal 2: 100% equitable access to water

In this scenario, everyone in New York City has access to a safe and adequate amount of potable water.

The emphasis of this goal is on a rights-based approach to water access and a commitment to eliminating inequalities.

Specific strategies and targets to achieve this goal include:

Affordable water access

- Water pricing based on tier use and income
- Make access to adequate and safe potable water affordable for all as part of 'City Bill of Rights'

Goal 3: Landscapes are conserved and managed to be resilient and protect water

This goal explores water conservation, stormwater, and water reuse infrastructures to ensure resilient water use and quality in the urban environment.

A shift to drought tolerant vegetation helps to protect water supply by reducing outdoor water use and enhances the resilience of the ecological system to severe drought conditions. Public, residential, and commercial properties capture greywater and rainwater for on-site use and all water runoff from impervious surfaces is managed for future banking and security. Specific strategies and targets to achieve this goal include:

Ecosystem-based strategies for drought

- Increase drought tolerant vegetation in urban green areas
  - Extensive blue-green coastal belt of drought/salt tolerance vegetation
  - Landscape designs and guidelines incorporate drought tolerant species and rainwater & graywater use for irrigation

Water conservation and recycling

- Gray water, water efficiency, and other water conservation and reuse measures are readily available for all buildings, landscapes
  - Incentives to retrofit buildings with low water use appliances (start with opportunities for under-resourced communities)
  - Increase permeable pavement on roads, sidewalks, other surfaces
- No (0%) potable water is used for non-potable uses
- Extensive centralized and decentralized system for aggressive stormwater capture, storage, and conveyance
- Parks shift to non-potable water for irrigation
- Clarify and develop health regulations on gray water reuse
- Education programing to increase awareness and willingness to use and adoption

Timeline: Resilience to Drought

Timelines for addressing the Drought and Shifting Water Demand adaptation and resilience goals: Workshop participants developed a detailed near-term (present day to 2035) and a longer-term (present day to 2100) timeline of strategies to achieve their 2100 goals. Zoom-in to see the details. The large circles represent the scenario goals for 2100. The squares represent individual strategies to achieve these goals and are color-coded by theme. Strategies connected by a line build on one another over time to achieve the end goal. Finally, the smaller circles within the timeline represent specific targets for goals.

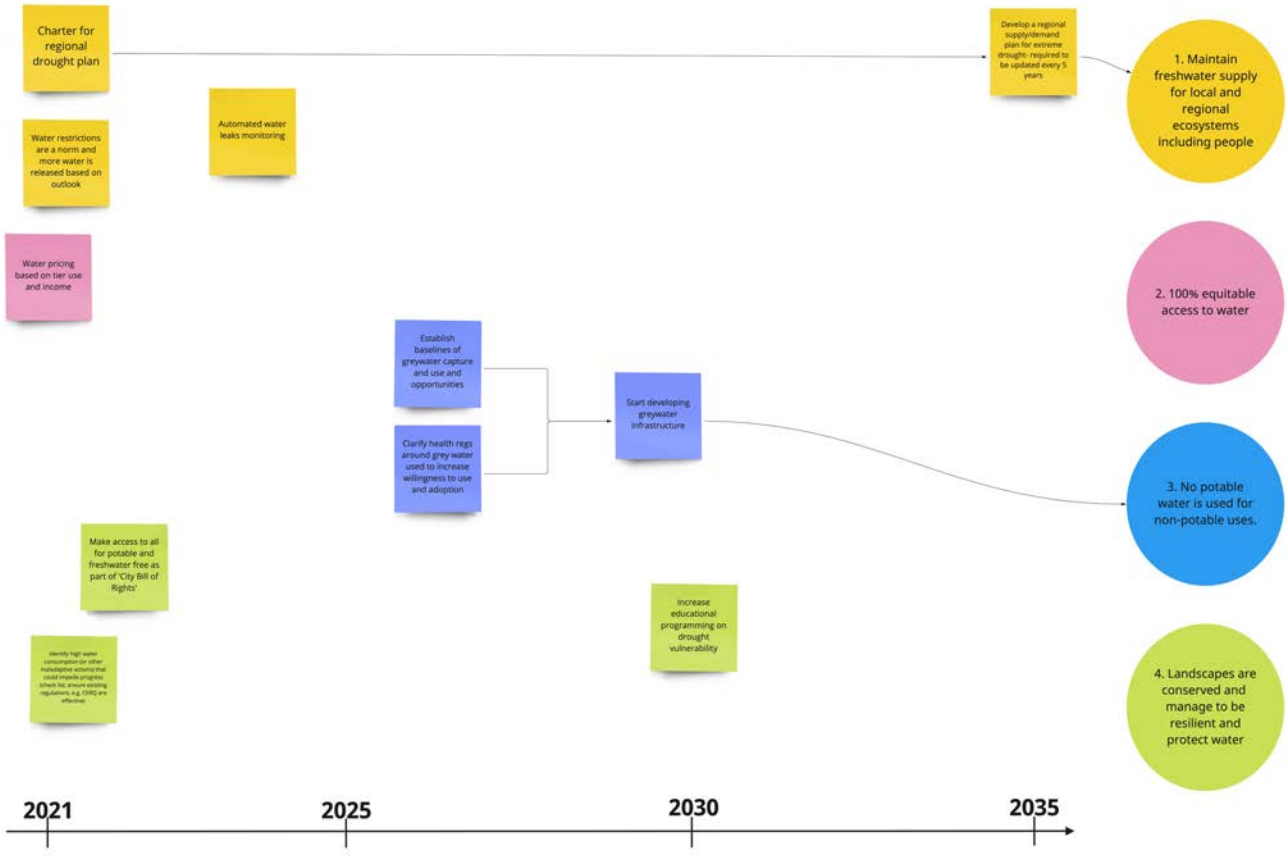


Figure 24. Near-term drought timeline co-developed by workshop participants

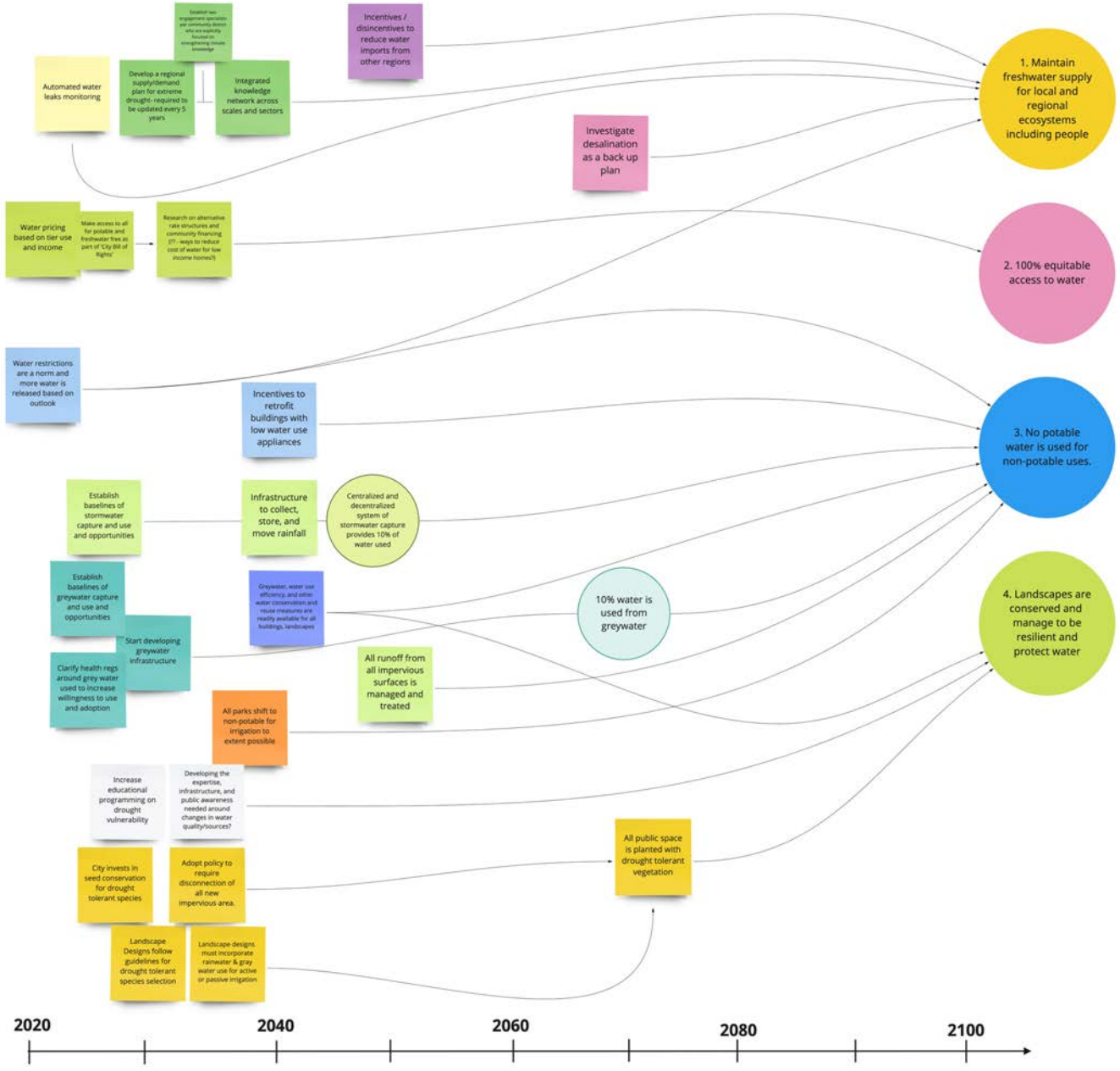


Figure 25. Long-term drought timeline co-developed by workshop participants

A day-in-the-life narrative: Drought Scenario

Drawing from the goals, strategies, and targets that the workshop participants envisioned during the workshops, the day-in-the-life stories imagine how the city would look and feel in the future.

"Okay, so what are we thinking for Jordan's birthday party? It's the first one after starting school so I think we should do something we could invite the class and some of the neighborhood kids to. I think we budgeted enough to have cake and buffet-style food for a decent-sized group."

"Well, school will have just ended, it'll be pretty warm, so maybe something outside to enjoy the summer. The kids could play with water balloons or something like that."

"We should definitely arrange for a park permit then. I don't think we want to pay the above-average water use fee.

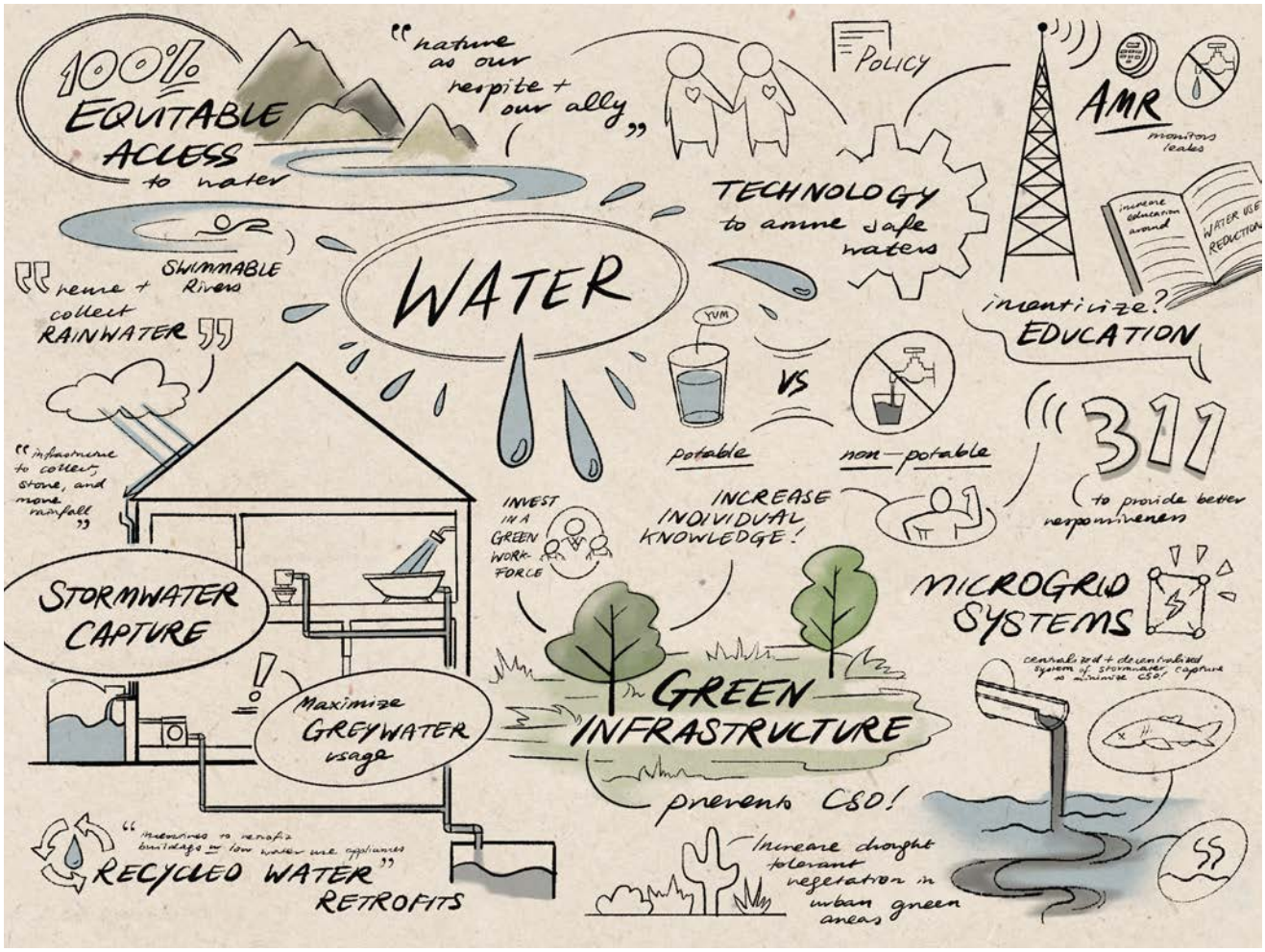


Figure 26. Drought scenario visualization, Artist: Rose Zhang

...Remember what happened when Jordan figured out how to turn on the tap? No thanks! Especially not right now when the Regional Water Compact just issued drought-time conditions for 2100-2105. We definitely don't have that in the budget. Best to look at the times the splash pad is active and schedule the party to take advantage of that."

"Good thinking. That should also put a nice time limit on their play time so they don't get overtired. I'm sure I'm not the only one who doesn't want the day to end with 20 cranky five-year-olds."

"Aha, the Saturday after Jordan's birthday our splash pad is open 12pm – 4pm. Because of drought conditions it'll be off during the week, even though it'll be summertime. The composting toilets will also be fresh since our park gets serviced on Fridays. I'll go ahead and submit the permit application now. The kids can always use the playground equipment after the splash pad turns off."

"Perfect. I will get the contact list from Jordan's teacher tomorrow and start designing an invitation with Jordan. We'll want to make sure everyone knows to wear their swimsuits."

NEW YORK CITY CLIMATE ADAPTATION SCENARIOS WORKSHOP SERIES

Cross-Cutting Strategies

ABOUT THE CROSS-CUTTING STRATEGIES

The solutions and strategies needed to address different hazards, such as coastal flooding and extreme precipitation, often have synergies and cross-cutting implications across different sectors and agencies. Workshop participants explored strategies to address particular hazards. In the following sections, we synthesize strategies across broader, **cross-cutting themes**: **water**, **social resilience**, **infrastructure**, **energy**, and **governance**. Government and community entities have already begun working on many of these ideas. Identifying the synergies and areas of crossover can help create efficiencies and expose possible trade-offs in climate adaptation planning across different sectors and agencies. We offer the cross-cutting ideas as building blocks to be further developed through joint work and collaboration.

Cross-cutting Strategies: Water

Water governance and management

- Integrated watershed management [Extreme Precipitation]
- Collaborative interagency relationships with agile, effective sharing of skills, data, and staff with transparency during multiple events. Roles and responsibilities are anticipated and clearly defined across agencies prior to an emergency [Multi-hazard]
- Regional water supply and demand plan (updated every five years) [Drought]
- Incentives/disincentives to reduce water imports from other regions [Drought]
- Enforcement of rules, guidelines, and codes on how to handle water on properties [Coastal flooding]
- Create standards for waterfront edge elevations [Coastal flooding]

Engineered infrastructure to manage water and energy

- Separate combined sewer systems to allow for grey water reuse [Extreme Precipitation]
- Capture and reuse of stormwater runoff [Extreme Precipitation]
- Installation of hydro power generation in wastewater system in order to generate enough capacity to self-power sewer and wastewater system [Multi-hazard]
- Base the prioritization of infrastructure investments on vulnerability [Extreme Precipitation]
- Focus on multi-functionality and co-benefits of new resilient infrastructure [Coastal flooding]
- Integrate cloudburst management practices [Extreme Precipitation]

Coastal shoreline adaptation

- Identification of soft and hard shorelines to adapt and elevate, and which areas may be part of longer-term retreat discussions by 2025 [Multi-hazard]
  - Adapt 50% of low-lying hard shorelines to meet the 90th percentile 2080s sea level rise (SLR) projections; be ahead of schedule by 2045
  - Adapt 100% of low-lying hard shorelines to meet the 90th percentile 2080s sea level rise projections by 2070
- Restoration and adaptation of existing at-risk salt marshes and soft shorelines [Multi-hazard]
  - At least 50% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s sea level rise projections by 2045
  - Restoration of 100% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s sea level rise projections by 2070
- Create standards for waterfront edge elevations [Coastal flooding]
- Adjust regulations to allow undeveloped areas (i.e., areas of future urban infill) to be preserved for ecological benefits and purposes [Coastal flooding]

Nature-based solutions to manage water

- Mimic biological processes alongside built environment and connect large, naturalized systems to urban neighborhoods to recreate a natural watershed for conveyance and recreation [Extreme Precipitation]
  - Semi-natural streetscape design, such that transport spaces of highway systems and tunnels can be reutilized for water conveyance during flood events
  - Repurpose high risk areas into productive uses, such as natural ecosystems, parks/recreation, etc.
  - Build larger scale stormwater capture or detention to complement green infrastructure
  - Implement natural conveyance system for moving water quickly
    - 100% conversion of impervious to pervious surfaces
- Integrate cloudburst management practices [Extreme Precipitation]
- Daylight streams [Extreme Precipitation]
- Look at best practices from other cities to speed up drainage for preventing disease risk associated with surface water [Extreme Precipitation]
- Use natural systems to reduce stormwater runoff in all parts of the city not just inundated areas [Extreme Precipitation]
- In retrofitting the city with resilient infrastructure, focus on system's approach with nature-based solutions and engineering with nature [Coastal flooding]
- Adjust regulations to allow undeveloped areas (i.e., areas of future urban infill) to be preserved for ecological benefits and purposes [Coastal flooding]
- Invest in and fund network of community land stewards of green spaces leading to the eventual establishment of land trusts that can be preserved for water conveyance [Extreme Precipitation]
- Increase drought tolerant vegetation in urban green areas [Drought]
  - Extensive blue-green coastal belt of drought/salt tolerance vegetation
  - Landscape designs and guidelines incorporate drought tolerant species and rainwater & graywater use for irrigation

Affordable water access

- Water pricing based on tier use and income [Drought]
- Make access to adequate and safe potable water affordable for all as part of 'City Bill of Rights' [Drought]
- No (0%) potable water is used for non-potable uses. [Drought]
  - Extensive centralized and decentralized system for aggressive stormwater capture, storage, and conveyance
  - Parks shift to non-potable for irrigation
  - Clarify and develop health regulations on gray water reuse
  - Education programing to increase awareness and willingness to use and adoption

Emergency preparedness and response

- All communities by 2030 will have resiliency hubs that can support, educate, and provide resources for multi-hazard resilience. In this case, resiliency hubs were envisioned as physical community spaces, such as libraries, that can support communities in preparation, recovery, and resilience during extreme events. [Multi-hazard]
- Investment in low income, disadvantaged communities to improve resilience in face of flooding [Coastal flooding]
- Improve flash flood response procedures [Extreme Precipitation]
- Shelter in place options and emergency methods for getting to higher ground for all (at work, in transit, at home) [Extreme Precipitation]

Expanding access to flood insurance

- Reform insurance system toward existing government coverage by 2030 [Multi-hazard]
- Equitable flood insurance [Coastal flooding]
- Expand access to flood insurance and recovery resources to areas outside of coastal flood zones, but vulnerable to extreme precipitation, and / or multi-hazards [Extreme Precipitation]
    - Include default flood insurance from any type of flooding in all policies for property owners and renters

Access to information and predictive models

- Provide information for the public to assess individual flood risks [Extreme Precipitation]
- Improve risk information flows around general precipitation risk, including on disease risks associated with more surface water [Extreme Precipitation]
- Improve predictive modeling for better ability to assess risk and plan amidst uncertainty [Extreme Precipitation]
- Revise federal Benefit Cost Analysis to encourage nature-based solutions that provide multiple benefits [Coastal flooding]
- Expand NYCHA Youth Program (2020) - Education for children in tune with future projections of flooding [Coastal flooding]
- Build an educated and engaged community by integrating an environmental design curriculum starting in middle school [Coastal flooding]
- Increase educational programming on drought vulnerability [Drought]

Housing mobility with resilient housing and relocation initiatives

- Build the capacity to temporarily house folks and expand affordable housing supply in lower risk areas [Extreme Precipitation]
- All residents live in affordable homes that are safe from sea level rise and large storm events. There will be no basement residences [Coastal flooding]
  - Equitable and affordable housing with price protection
- Building and maintaining trust to have honest conversations about retreat including beginning discussions with at-risk communities by 2030 and initiate retreat mechanisms by 2040 [Multi-hazard]
- Mechanisms to improve community resiliency without displacement by 2040 [Multi-hazard]
- Buy outs and relocation from flood vulnerable areas that account for diverse value systems, needs, and ability for self-determining relocation [Coastal flooding]

Building retrofits to manage water

- Building codes and policies with multi-hazard design requirements including by 2040, 100% of new buildings and major renovations to meet requirement [Multi-hazard]
- Design flexible, safe-to-fail buildings [Coastal flooding]
  - Codes in place for retrofitted buildings by 2025
  - Agreement between citizens and government regarding new structures by 2030
  - Retrofitting buildings for less waste by 2030
  - Buildings are multi-use by 2035
- All properties capture the runoff that they produce [Extreme Precipitation]
  - Reduce stormwater runoff flow by 30% into sewer systems by 2040
  - 100% reuse of captured stormwater for other purposes by 2050 (potable and non-potable)
- Automated, smart water leak detection [Drought]
- Gray water, water efficiency, and other water conservation and reuse measures are readily available for all buildings, landscapes [Drought]
  - Incentives to retrofit buildings with low water use appliances (start with opportunities for under-resourced communities)
  - Increase permeable pavement on roads, sidewalks, other surfaces

Cross-cutting Strategies: Social resilience

Educational programing on climate adaptation and resilience

- Youth education programs on climate action [Multi-hazard]
- Build an educated and engaged community by integrating an environmental design curriculum starting in middle school [Coastal flooding]
- Expand NYCHA Youth Program (2020) - Education for children in tune with future projections of flooding [Coastal flooding]
- Increased community-level educational programming and outreach on winter preparedness, building out citizen science initiatives [Winter extremes]
- Educate public on how to assess individual flood risks [Extreme Precipitation]
- Improve risk information flows around general precipitation risk, including on disease risks associated with more surface water [Extreme Precipitation]
- Educational component on the impact of heat on surface transportation [Heat]
- Establish engagement specialists for each community district who focus on strengthening climate knowledge [Drought]
- Increase educational programming on drought vulnerability [Drought]

Employment

- Investment in green and community-based economy with jobs guarantee & CUNY/SUNY pipeline [Multi-hazard]
- Increased tele-work and tele-health options for flexibility during winter weather [Winter extremes]

Community preparedness

- Improve predictive modeling for better ability to assess risk and plan amidst uncertainty [Extreme Precipitation]
- Focus on preventive planning and maintenance [Winter extremes]
- Improve flash flood response procedures [Extreme Precipitation]
- Consistent and robust public messaging and public warning systems regarding winter weather [Winter extremes]
- Early warning system (localized to neighborhoods) that encourages limited transit during events. [Winter extremes]
- Shelter in place options and emergency methods for getting to higher ground for all (at work, in transit, at home) [Extreme Precipitation]
- New mentality to enjoy winter weather and accept restrictions [Winter extremes]
- Investment in low income, disadvantaged communities to improve resilience in face of flooding [Coastal flooding]

Basic household services for water, heat, and cooling

- 100% access to heating/cooling [Winter extremes]
- Anyone who qualifies or applies for LIHEAP will be given access [Winter extremes]
- Universal access to sustainable cooling [Heat]
- Make access to adequate and safe potable water affordable for all as part of 'City Bill of Rights' [Drought]
- Water pricing based on tier use and income [Drought]

Social networks and support

- Expand Be a Buddy for winter weather emergencies [Winter extremes]
- Expand Strengthening Communities through Recovery program [Winter extremes]
- Expand access to flood insurance / recovery resources to areas outside of coastal flood zones, but vulnerable to extreme precipitation, and / or multi-hazards [Extreme Precipitation]
- Include default flood insurance from any type of flooding in all policies for property owners and renters
- Reform insurance system toward existing government coverage by 2030 [Multi-hazard]
- Equitable flood insurance [Coastal flooding]
- Resiliency hubs with regular participation and contributions from government and non-government groups [Drought]
- All communities by 2030 will have resiliency hubs that can support, educate, and provide resources for multi-hazard resilience. In this case, resiliency hubs were envisioned as physical community spaces, such as libraries, that can support communities in preparation, recovery, and resilience during extreme events. [Multi-hazard]

Secure, safe, and affordable housing

- Housing available for all, housing as a right [Winter extremes]
- Affordable and safe housing for all [Multi-hazard]
- By 2100, 0% homelessness [Multi-hazard] / Zero homelessness [Winter extremes]
- Equitable and affordable housing with price protection [Coastal flooding]
- All residents live in affordable homes that are safe from sea level rise and large storm events. There will be no basement residences [Coastal flooding]
- Expand affordable housing supply in lower risk areas and develop more resilient building stock, including ensuring underground spaces are retrofitted for safety [Extreme Precipitation]
- Build capacity to temporarily house people [Extreme Precipitation]
- Rapid implementation of emergency shelter during storm or cold snap events [Winter extremes]

Health and healthcare access

- 100% access to resources for mental health needs [Multi-hazard]
- 100% healthcare access by 2080 including creation of one-payer health system (no longer "health industry") [Multi-hazard]
- One-payer health system has 70% adoption rate by 2060;
- 100% healthcare access by 2080 and equitable access for all New Yorkers
- Improve access to NYC Health and Hospitals Corporation (HHC) clinics and quality of care as initial mechanism to improve affordable access by 2025 [Multi-hazard]
- Universal access to quality, single-payer healthcare [Heat]
- Mandatory cooling breaks and limited hours for outdoor, active workers in excessive heat. Required micro-cooling centers and break rooms. Make OSHA standards that relate to heat. [Heat]
- Ensuring community health with a focus on hypothermia or other illnesses, including no carbon monoxide poisoning resulting from heating or gas use in homes [Winter extremes]
- Build schools, hospitals, and mixed-use districts evenly across the habitable areas [Multi-hazard]

Transportation safety

- Transportation system focused on safely moving people, not managing cars [Multi-hazard]
- High mobility safety [Winter extremes]
- Enforcement of safety and traffic laws including expanding to automated enforcement by 2023 [Heat]
- Early warning system (localized to neighborhoods) that encourages limited transit during events. [Winter extremes]
- Improve wheelchair and other accessibility for people with disabilities and for the elderly [Winter extremes]
- Passive strategies for heated sidewalks and roadways to accelerate ice and snow melt and stop salting [Winter extremes]
- Base the prioritization of infrastructure investments on vulnerability [Extreme Precipitation]
- Update codes to include shade requirements [Heat]
- 50% of open space is shaded [Heat]

Cross-cutting Strategies: Infrastructure

Transportation infrastructure

- Replace all city heavy duty vehicles with electric vehicle (EV) options and/or super low greenhouse gas emitting biofuels by 2060 [Multi-hazard]
- Create long-term plan to build electric vehicle transmission into the major highway and bridge maintenance cycle by 2035 [Multi-hazard]
  - 50% of major highways to allow for powering electric vehicles in at least 50% of available lanes by 2060;
  - 100% of major highways to allow for powering electric vehicles in at least 50% of available lanes by 2080
- Invest in freight and maritime infrastructure in order to reduce truck traffic in the city. Remaining trucks and cars are electric vehicles [Heat]
  - 80% reduction in truck traffic
- No private street parking and no parking minimums in building regulations [Heat]
  - 50% of street parking spaces are repurposed by 2030
- Transform water, energy, and roadway and public transit infrastructure to withstand freeze-thaw cycles [Winter extremes]

Public Transportation

- Ensure that all New Yorkers are well-served by green and efficient public transit [Heat]
  - Expanded access to people-based, better networked public transit
  - Car-free zones
  - Bike infrastructure prioritized over private cars with >50% travel lanes for bikes
  - More subways, Bus Rapid Transit, and better network
- Ensure public transportation and bike lanes are fully functional year-round. Bikes treated equally to roads [Winter extremes]
- Pedestrian covered and heated bridges and underground pedestrian tunnels to encourage people to leave their homes [Winter extremes]

Building codes and design

- Building codes and policies with multi-hazard design requirements including by 2040, 100% of new buildings and major renovations to meet requirement [Multi-hazard]
- Design flexible, safe-to-fail buildings [Coastal flooding]
  - Codes in place for retrofitted buildings by 2025
  - Agreement between citizens and government regarding new structures by 2030
  - Retrofitting buildings for less waste by 2030
  - Buildings are multi-use by 2035
- Integrate natural carbon sequestration into architecture (green spaces, water, algae) [Coastal flooding]
- Require green roof installation retrofits [Heat]
  - 90% of roof space is green or solar by 2060

Nature-based solutions and green infrastructure

- Identification of soft and hard shorelines to adapt and elevate, and which areas may be part of longer-term retreat discussions by 2025 [Multi-hazard]
  - Adapt 50% of low-lying hard shorelines to meet the 90th percentile 2080s Sea Level Rise projections; be ahead of schedule by 2045
  - Adapt 100% of low-lying hard shorelines to meet the 90th percentile 2080s Sea Level Rise projections by 2070
- Restoration and adaptation of existing at-risk salt marshes and soft shorelines [Multi-hazard]
  - At least 50% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s SLR projections by 2045
  - Restoration of 100% of existing at-risk salt marshes and soft shorelines for 90th percentile 2080s SLR projections by 2070
- Water features for evaporative cooling, such as misters or ponds [Heat]
  - 15% of neighborhood space includes water features
  - Reclaim curb space for green infrastructure, including tree canopy
- Green infrastructure (right of way) and cool corridors [Heat]
  - Increase green space and natural infrastructure including green facades by 50%
- Mimic biological processes alongside built environment and connect large, naturalized systems to urban neighborhoods to recreate a natural watershed for conveyance and recreation [Extreme Precipitation]
  - Semi-natural streetscape design, such that transport spaces of highway systems and tunnels can be reutilized for water conveyance during flood events
  - Repurpose high risk areas into productive uses, such as natural ecosystems, parks/recreation, etc.
  - Build larger scale stormwater capture or detention to complement green infrastructure
  - Implement natural conveyance system for moving water quickly
    - 100% conversion of impervious to pervious surfaces
- Integrate cloudburst management practices [Extreme Precipitation]
- Daylight streams [Extreme Precipitation]
- Use natural systems to reduce stormwater runoff in all parts of the city not just inundated areas [Extreme Precipitation]
- Increase drought tolerant vegetation in urban green areas [Drought]
  - Extensive blue-green coastal belt of drought/salt tolerance vegetation
  - Landscape designs and guidelines incorporate drought tolerant species and rainwater & graywater use for irrigation

Cross-cutting Strategies: Energy

Energy Infrastructure

- Development of fully resilient energy grid with significant increase in renewables [Multi-hazard]
  - Maximize solar energy production on building roofs where possible by 2090
  - Maximize wind energy production on near shore areas by 2100
  - Introduce regulatory reform to change incentives (e.g., grid currently run by companies that have profit as end goal which is disincentive for long-term investments in hardening the grid against climate threats)
- Installation of hydro power generation in wastewater system in order to generate enough capacity to self-power sewer and wastewater system [Multi-hazard]
- Cogeneration of power via publicly owned power generation system [Multi-hazard]
- Universal access to sustainable cooling [Heat]
- Transform water, energy, and roadway and public transit infrastructure to withstand freeze-thaw cycles [Winter extremes]
- More underground electric lines [Winter extremes]
- Invest in clean, reliable fuel sources to keep heating equipment functional [Winter extremes]

Building-energy infrastructure

- Incentivize and regulate building retrofits to improve energy efficiency and insulation [Winter extremes]
- Require use of passive house/low-energy building design [Heat]
  - Update building codes to require low-energy design and meet indoor air quality standards
- Retrofit and build with heat recovery systems [Heat]
  - 100% of buildings are heat sinks by 2085
- Update building codes to reduce the use of absorptive materials [Heat]
  - Building code scoring for building heat footprint
  - Update building codes to require low-energy design and meet indoor air quality standards by 2050
- Incentivize retrofits
- Invest in extensive electric in-home heating [Winter extremes]
  - 100% electric in-home heating by 2050

Cross-cutting Strategies: Governance

Workshop 3 in our five-workshop series focused on governance, where we asked participants to think beyond the current governance structure and imagine: ***How do we envision a sustainable, resilient, and equitable future governance model for 2100?*** To guide the discussion, participants were presented with principles of resilience governance: Diversity and participation; Adaptive and flexible; Transparent and accountable; Decentralized governance structure; Experimentation, innovation, and learning to evolve with uncertainty and respond to new information; Collaboration and co-production; and Unlocking to recognize and phase out mal-adaptations.

The following is a synthesis of characteristics for a future governance model in New York City that participants shared:

A future governance model for NYC would emphasize a flexible approach to governance, sharing and coordinating resilience responsibility across city agencies. The resiliency-focused governance model would integrate long-term planning and addressing systemic challenges beyond the mayoral cycle. Using a watershed model that crosses political boundaries, there would be strong multi-scale governance networks at neighborhood, city, state, and regional levels. It would include more stringent mechanisms for accountability and transparency, including review of elected officials and integrated assessments that measure multiple benefits, failures, and their consequences. Future city government would have transformative, diverse, and visionary leadership and be a place of empowerment and enthusiasm that maintains belief in governance institutions.

In terms of budgeting and financing, the city could rely on multi-purpose budgeting tied to objectives instead of specific projects and include participatory budgeting at a citywide scale. Resiliency focused budgeting would also center divesting and disincentivizing investments in fossil fuels, which the city has already begun to do. Aligned with equity and justice goals, the resiliency governance model would ensure equitable prioritization of strategies and investments by tying funding to equity metrics.

To build citizen participation in planning and democratize engagement, communities would be engaged early in the planning phase through a bottom-up, community-owned process that is respectful of people's time and mindful of inherent power dynamics. Community groups would be compensated for their participation and funding would be designated toward community visioning, including those most impacted. Redundancies in community engagement processes and input would be addressed by creating channels for cross-agency coordination of parallel engagement efforts and an ad hoc group to synthesize community input to inform policy recommendations. Resiliency hubs would be established with regular participation and contributions from government and non-government groups.

Below is a list of responses from all participants that informed the synthesis:

Government structure: Distributing authority, responsibility, and financial resources across neighborhood, city, regional, and state governance with new roles and functions

- Transformative, diverse, and visionary leadership who inspire people
  - City government is a place of empowerment and enthusiasm, sustaining morale and belief in governance institutions
- Steering committee or advisory board that delegates responsibility, money, etc.
- Multi-scale governance model including regional to hyper-local governance
  - Integrated decision-making that occurs across sectors, multiple agencies, and neighborhoods to regions
  - Coordination, engagement, and transparency between city, regional, and federal partners
  - Use watershed boundaries for governance structure, rather than political boundaries, to create regional networks and increase communication among states
  - Reframing climate issues as regional problems
- Resilience responsibility shared across city governance
  - Governance entity that coordinates planning for different hazards across agencies
  - New agency structures with adaptable roles during emergencies
  - All city agencies have funding to hire the necessary staff with resilience focus to ensure a multi-hazard perspective
  - Interagency and community collaboration before, during, and after events
  - City agency for resilience that is separate and independent from Mayor's office (to reduce impact of mayoral turnover on progress and values)
- Establish a separate office dedicated to address equity and conduct more stringent environmental reviews—requiring analysis of disparate impact on EJ communities
- Re-envision responsibilities of agencies for implementation and maintenance of green infrastructure

Accountability and transparency in governance through assessment and monitoring: Clarifying roles and responsibilities of agencies and individuals working on urban resilience initiatives, as well as assessment and monitoring mechanisms

- Mechanisms for reviewing elected officials and leadership, especially to ensure fair and successful implementation
  - Establish forum for accountability, such a process for the public to review elected officials every two years
- Governance system that rewards executing a plan, not just developing one
- Integrated assessments that measure multiple benefits (and failures and their consequences) across timescales
  - Measure success by comparing to long-term goals
  - Create performance metrics for private investments and infrastructure projects
- Coordination, engagement, and transparency between city, regional and federal partners
- Integrate opportunities for input from community to increase transparency and accountability in how resiliency decisions are made

Budget and financing: Diversifying mechanisms to fund resiliency efforts equitably across communities and into the long-term future

- Steering committee or advisory board that delegates responsibility, money, etc.
- Implement new funding entity that brings in and distributes funding based on resilience principles and has bonding authority
  - Establish resiliency code of ethics
  - Funding is tied with equity and accountability metrics
- Generating new revenue streams (e.g., crowd source donations, community bonds) that incorporate resilience governance
- Participatory budgeting that occurs at citywide scale
- Increase accessibility to funding opportunities and non-discretionary funding
- Rethink city as epicenter of finance, including divesting and disincentivizing fossil fuels, and finding mechanisms for each system to pay its own externalities
- Multi-purpose budgeting with larger discretionary budgets tied to long-term objectives rather than specific projects

"One of the unsuitable ideas behind projects is the very notion that they are projects, abstracted out of the ordinary city and set apart...The aim should be to get that project, that patch upon the city, rewoven back into the fabric – and in the process of doing so, strengthen the surrounding fabric too."

- Jane Jacobs, The Death and Life of Great American Cities (Chapter 20)

Anticipatory planning with adaptive, flexible governance: Facilitating forward-looking, robust, flexible decision making in the face of uncertainty and complexity.

- Mechanisms and funding to integrate future visioning with communities into planning
- A future governance model that makes room for addressing large-scale, systemic challenges, and allows for planning and acting beyond the mayoral cycle
- Governance system that encourages “fail fast, fail forward”
- New agency structures with adaptable roles during emergencies
- Embed flexibility and coordination into the preparation phase, including exercises and trainings that prepare government agencies and community to be flexible when responding to events
  - Incorporate community knowledge and resilience practices in the exercises
- Capacity building within agencies for retreat, including understanding of roles for acquisition and management of land, as well as creating value in community use and stewardship of land

Equity and justice: Fostering and prioritizing inclusion and equitable decision making

- Governance is community-driven with visioning from bottom-up
- Ensure equitable prioritization of strategies and investments
  - Funding is tied with equity and accountability metrics
  - Reframe policies, mandates, and requirements to explicitly address equity and include fair share principles to examine benefits and burdens
  - Increase accessibility to funding opportunities, non-discretionary funding
- Reframe “planet issues” as “people problems”
- Establish resiliency code of ethics
- Make participation more accessible, e.g., with open source, free platforms for input
- Recognize multiple ways of knowing and not professionalizing how people participate

Diverse participation and community engagement in governance: Addressing local needs by integrating multiple sources of knowledge, power and resources, and fostering ownership, trust, buy-in, and shared understanding

- Governance is community-driven with visioning from bottom-up
- Mechanisms and funding to integrate future visioning with communities into planning
- Build capacity of civic groups and elevate their power in order to rebalance power structures
- Interagency and community collaboration before, during, and after events
  - Resiliency hubs with regular participation and contributions from government and non-government groups
- Make participation more accessible
  - Engage community stakeholders, including businesses and commerce, early in development and planning process
  - Ad hoc group that synthesizes community input and knowledge
  - Open source, free platforms for input
  - Public input shapes projects but the process recognizes how existing power structures may impact the people giving feedback
- Change comes from the bottom-up where governance starts with the people
  - People are informed about resiliency in order to help govern
- Participatory budgeting at citywide scale
- Increase accessibility to funding opportunities, including non-discretionary funding
- Establish mechanism that enable community ownership and maintenance of projects
- Move towards co-creation, away from uni-directional, prescriptive design
- Reimagine collaboration mechanisms across government agencies, as well as public and private sectors
- Democratizing engagement through the co-creation of ideas in local partnerships and networks, where people are compensated for their time and contribution
- Address community input redundancies through government coordination
  - Use existing sources of information for community input (e.g. social media)
  - Create channels for community knowledge to be communicated back to government

Feedback on the Scenarios Process

Based on an exit survey at the end of the workshop series, participants noted what they liked, things they wanted to see changed, and ideas they wanted to discuss more.

Participants acknowledged the novel opportunity for cross-agency collaboration and to think transformatively. Both were key objectives of the workshop at the outset. The Convergence team intentionally engaged climate resiliency and adaptation experts across many sectors and distributed the diverse expertise among small groups. Small group discussions urged participants to think boldly, positively, and imaginatively about the future of climate adaptation in the city.

> ***"There really hasn't been any good mechanism for people to meet and collaborate outside of specific work tasks and it's precisely in that open-ended space that the evolution would happen."***
>
> – Workshop Participant

Some participants noted the need for even more space and time to discuss the details of their scenarios. In particular, there was a desire for more time to discuss the diversity of ideas generated in the workshop and create actionable and feasible next steps. This report is one step toward extending the conversation by synthesizing the content and ideas created during the workshop series and expanding upon them with 'day in the life' stories of each future scenario. While many appreciated the chance to meet people from across agencies, they also wanted more opportunities for networking. Multiple MOCEJ initiatives, including the AdaptNYC planning process, will engage across multiple agencies and build on the collaborations that were built during the workshop series.

References

González, J. E., Ortiz, L., Smith, B. K., Devineni, N., Colle, B., Booth, J. F., ... Rosenzweig, C. (2019). New York City Panel on Climate Change 2019 Report Chapter 2: New Methods for Assessing Extreme Temperatures, Heavy Downpours, and Drought. Annals of the New York Academy of Sciences, 1439(1), 30-70. https://doi.org/10.1111/nyas.14007

Gornitz, V. M., Oppenheimer, M., Kopp, R., Orton, P., Buchanan, M., Lin, N., ... Bader, D. A. (2019). New York City Panel on Climate Change 2019 Report Chapter 3: Sea Level Rise. Annals of the New York Academy of Sciences, 1439(1), 71-94. https://doi.org/10.1111/nyas.14011

Grimm, N. B., Cook, E. M., Hale, R. L., & Iwaniec, D. M. (2015). A broader framing of ecosystem services in cities: Benefits and challenges of built, natural, or hybrid system function. Routledge Handbooks Online. https://doi.org/10.4324/9781315849256.ch14

Knowlton, K., Lynn, B., Goldberg, R. A., Rosenzweig, C., Hogrefe, C., Rosenthal, J. K., & Kinney, P. L. (2007). Projecting heat-related mortality impacts under a changing climate in the New York City region. American Journal of Public Health, 97(11), 2028-2034. https://doi.org/10.2105/AJPH.2006.102947

Markolf, S. A., Chester, M. V., Eisenberg, D. A., Iwaniec, D. M., Davidson, C. I., Zimmerman, R., Miller, T. R., Ruddell, B. L., & Chang, H. (2018). Interdependent Infrastructure as Linked Social, Ecological, and Technological Systems (SETSs) to Address Lock-in and Enhance Resilience. Earth's Future, 6(12), 1638–1659. https://doi.org/10.1029/2018EF000926

McPhearson, T., Haase, D., Kabisch, N., & Gren, Å. (2016). Advancing understanding of the complex nature of urban systems. Ecological Indicators, 70, 566–573. https://doi.org/10.1016/j.ecolind.2016.03.054

McPhearson, T., Cook, E. M., Berbés-Blázquez, M., Cheng, C., Grimm, N. B., Andersson, E., Barbosa, O., Chandler, D. G., Chang, H., Chester, M. V., Childers, D. L., Elser, S. R., Frantzeskaki, N., Grabowski, Z., Groffman, P., Hale, R. L., Iwaniec, D. M., Kabisch, N., Kennedy, C., … Troxler, T. G. (2022). A social-ecological-technological systems framework for urban ecosystem services. One Earth, 5(5), 505–518. https://doi.org/10.1016/j.oneear.2022.04.007

NPCC. (2013). Climate Risk Information 2013: Observations, Climate Change Projections, and Maps. C. Rosenzweig and W. Solecki (Eds.), NPCC2, 1-38.

NPCC. (2015). Building the Knowledge Base for Climate Resiliency: New York City Panel on Climate Change 2015 Report. C. Rosenzweig and W. Solecki (Eds.). Annals of the New York Academy of Sciences, 1336(1), 1–149.

References

NPCC. (2019). Special issue: Advancing Tools and Methods for Flexible Adaptation Pathways and Science Policy Integration: New York City Panel on Climate Change 2019 Report. C. Rosenzweig and W. Solecki (Eds.). Annals of the New York Academy of Sciences, 1439(1), 1-354.

Orton, P., Lin, N., Gornitz, V., Colle, B., Booth, J., Feng, K., Buchanan, M., Oppenheimer, M., & Patrick, L. (2019). New York City Panel on Climate Change 2019 Report Chapter 4: Coastal Flooding. Annals of the New York Academy of Sciences, 1439(1), 95–114. https://doi.org/10.1111/nyas.14011

Petkova, E. P., Vink, J. K., Horton, R. M., Gasparrini, A., Bader, D. A., Francis, J. D., & Kinney, P. L. (2017). Towards more comprehensive projections of urban heat-related mortality: estimates for New York City under multiple population, adaptation, and climate scenarios. Environmental Health Perspectives, 125(1), 47-55. https://doi.org/10.1289/EHP166

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