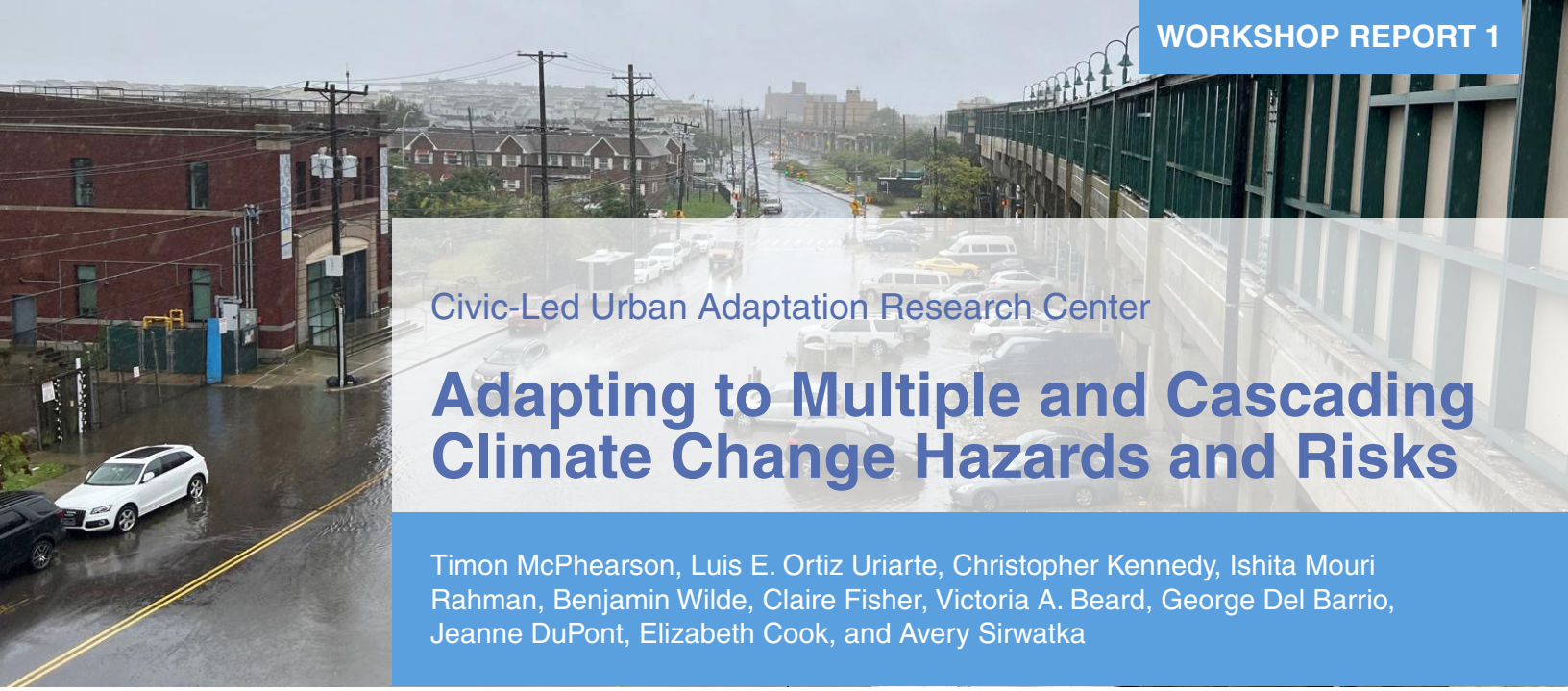

WORKSHOP REPORT 1

Civic-Led Urban Adaptation Research Center

Adapting to Multiple and Cascading Climate Change Hazards and Risks

Timon McPhearson, Luis E. Ortiz Uriarte, Christopher Kennedy, Ishita Mouri Rahman, Benjamin Wilde, Claire Fisher, Victoria A. Beard, George Del Barrio, Jeanne DuPont, Elizabeth Cook, and Avery Sirwatka

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HIGHLIGHTS

» Climate change adaptation efforts by the New York City government are not well coordinated, but rather are siloed in various departments.

» Inadequate communication and knowledge-sharing between city government and communities limits the effectiveness of climate change adaptation strategies.

» Significant knowledge gaps exist around the combined effects of multiple and cascading climate change hazards and the effectiveness of existing policies and strategies in New York City.

» Climate change adaptation research should continue to engage a diverse set of stakeholders, including scientists, policymakers, industry experts, and community leaders.

» Active involvement of communities affected by climate hazards is critical in informing policies that reflect firsthand experiences and local knowledge.

Workshop Reports contain preliminary analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues.

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This work is supported by the National Science Foundation award #2334311.

PROJECT OVERVIEW

The project is a one-year planning grant from the National Science Foundation (NSF) to develop a new Civic-Led Urban Adaptation Research Center (CIVIC-UARC) for New York City. The project brings together urban experts from across multiple disciplines and institutions, civil society organizations, and communities to support equitable, sustainable, and inclusive approaches to urban adaptation, assisted by innovative technologies. The team also engages NYC-based government agencies and private industry. Beyond creating new knowledge specific to New York City, the new Center aspires to produce useful research for cities across the U.S. that are grappling with climate change in the context of rising inequality and a legacy of environmental injustice. It will educate and train the next generation of investigators, change agents, and decision-makers working on just and equitable urban climate change adaptation. The work for the planning grant and the work of the new Center focus on three core research areas:

1. Adapting to Multiple and Cascading Climate Change Hazards and Risks

Effective, equitable, and timely adaptation planning requires a nuanced and comprehensive understanding of the hazards and risks associated with a rapidly changing climate. This research area, including a workshop on February 14, 2024, focuses on improving our understanding of how climate change hazards are spatially distributed across the city and how human behavior and activity, the urban built environment, and natural processes interact with one another. This research area is focused on multiple and cascading climate change hazards and the drivers of those hazards. The goal is to shed light on critical climate resilience challenges, with particular attention to pluvial and coastal flooding, urban heat and heat waves, and air pollution.

2. Climate Change Vulnerability and Community Capacity for Adaptation

An understanding of underlying community vulnerabilities and the capacity to respond to emerging climate threats is necessary for the equitable and effective allocation of climate adaptation resources. This report focuses on this research area and its associated workshop on February 15, 2024. Through them, the project team seeks to understand household and community capacity for care and climate vulnerabilities in two selected neighborhoods in New York City: Brownsville in Brooklyn and the Rockaways in Queens. The workshop drew on multiple data sources and existing vulnerability indices, but prioritized learning from residents' lived experiences and knowledge of sources of vulnerability and capacity.

3. Developing a Digital Twin for Climate Adaptation

Rapidly evolving digital technologies have the potential to support more coordinated and participatory urban interventions. This research area, including a workshop on March 15, 2024, examines the potential uses of a digital twin of New York City — a virtual representation of the city informed by live data streams from multiple sources — to support climate change adaptation. This workshop brought together panels of public sector and private industry experts. The aim is to create an open computational platform for decision-makers in the public and private sectors, researchers, civil society, and the general public to better understand climate-related issues and evaluate potential responses.

Image credit: Cornell Mui Ho Center for Cities

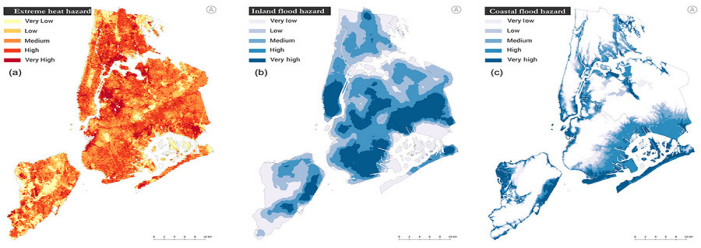


Image credit: Depietri, Dahal and McPhearson, 2018

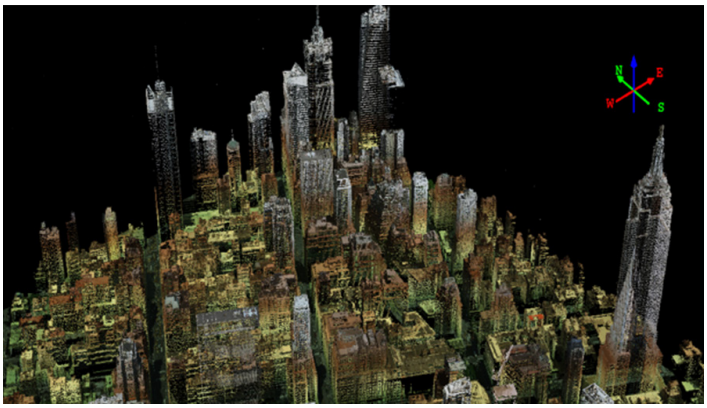


Image credit: Center for Analysis and Research of Spatial Information (CARSI Lab) at Hunter College – CUNY

WORKSHOP SUMMARY

On February 14, 2024, a team of researchers co-led by Timon McPhearson (The New School) and Luis E. Ortiz (George Mason University), in partnership with the community-based organizations RISE and Universe City NYC, hosted the "Adapting to Multiple and Cascading Climate Change Hazards and Risks" workshop. The participants were academic and municipal experts assembled through targeted outreach. The project team started with their own professional networks, which include leading experts in a variety of disciplines relevant to climate change adaptation in New York City. The project team also identified and invited potential participants from city government by searching through the websites of critical public sector agencies, then researched out to community members through our civil society partner's networks. All together, 24 people attended the workshop, including 11 from academia (both faculty members and students), 11 officials from New York City public agencies, and two representatives of community-based organizations (Table 1).

Table 1 - **Types of Workshop Stakeholders**

Sector	Participants
Academia	11
Public sector	11
Civil society	2
Total participants	24

The workshop was organized around three topics: 1) climate hazards; 2) climate risks, vulnerability and equity; and 3) compound hazards, cascading impacts, and relevant solutions. The participants were divided into small groups to discuss how New York City can best prepare for and adapt to two climate hazards—flooding and extreme heat—and address poor air quality, which can be exacerbated by climate change. Facilitators from the project team helped to structure the discussion and gather insights to better understand the impacts of current and future climate hazards in the city, as well as potential solutions and examples of effective response and preparedness.

The objective of this workshop was to generate new knowledge and explore the potential for community-led process to jointly develop equitable approaches to urban climate adaptation in New York City. The results, informed by a literature review, will be used to develop a funding proposal for a new research center (CIVIC-UARC) to collaborate and partner with community organizations and other stakeholders on adaptation in the city. This event was the first in a series of three workshops conducted throughout the winter and spring of 2024 to develop this proposal for the CIVIC-UARC.

To provide some context for the workshop discussions, Dr. Luis E. Ortiz Uriarte, assistant professor in the Department of Atmospheric, Oceanic, and Earth Sciences at George Mason University, presented preliminary results from the NYC Panel on Climate Change's 4th Assessment—

Photo 1 - **Workshop participants discuss climate hazards and impacts.**

Image credit: Melanie Chu

which, in turn, is informed by state- and national-level assessments. Following the presentation by Dr. Ortiz, Pablo Herreros Cantis, a visiting scholar at the Urban Systems Lab at The New School, gave a presentation on growing flood risks in the city, based on a new Flood Vulnerability Index (FVI) for NYC.

Alongside the workshops, the research teams have been conducting: (1) background research and a literature review to identify relevant knowledge gaps and institutional networks; (2) monthly virtual meetings of research teams and community partners; and (3) site visits to each of the community organizations involved. The CIVIC-UARC planning phase aims to catalyze new collaborations across academic disciplines and with institutions and partners in civil society and the public sector. It will generate new knowledge specific to New York City and enhance the climate resilience of local partners. It will also train a new generation of adaptation researchers and develop a coproduction approach to research and community engagement that could serve as a model for cities across the U.S., as it is designed to grapple with climate change in the context of rising inequality and historical environmental injustices.

The CIVIC-UARC planning phase aims to catalyze new collaborations across academic disciplines and with institutions and partners in civil society and the public sector.

WORKSHOP PROGRAM

8:30 – 9:00 a.m. | Registration and Opening Remarks

9:00 – 10:15 a.m. | Project Overview and Objectives of the Day

10:15 – 11:15 a.m. | Session 1: Climate Hazards and Impacts

Discussion of key drivers and impacts of air quality, extreme heat, and flooding exposure for critical infrastructure and communities.

11:15 a.m. – 12:30 p.m. | Session 2: Climate Risks, Vulnerabilities, and Equity

Discussion of key risks and vulnerabilities for air pollution, extreme heat, and flooding.

1:30 – 3:15 p.m. | Session 3: Compound Hazards, Cascading Impacts, and Multihazard Climate Solutions

Discussion of how infrastructure interdependencies could result in climate change impacts compounding and cascading. Discussion of knowledge and research gaps, as well as solutions to multiple hazards.

3:30 – 4:00 p.m. | Summary, Next Steps, and Closing

Photo 2 - **Workshop participants discuss flooding risk and resilience.**

Image credit: Melanie Chu

SESSION 1: CLIMATE HAZARD DRIVERS AND IMPACTS

EXERCISE FORMAT & DESCRIPTION

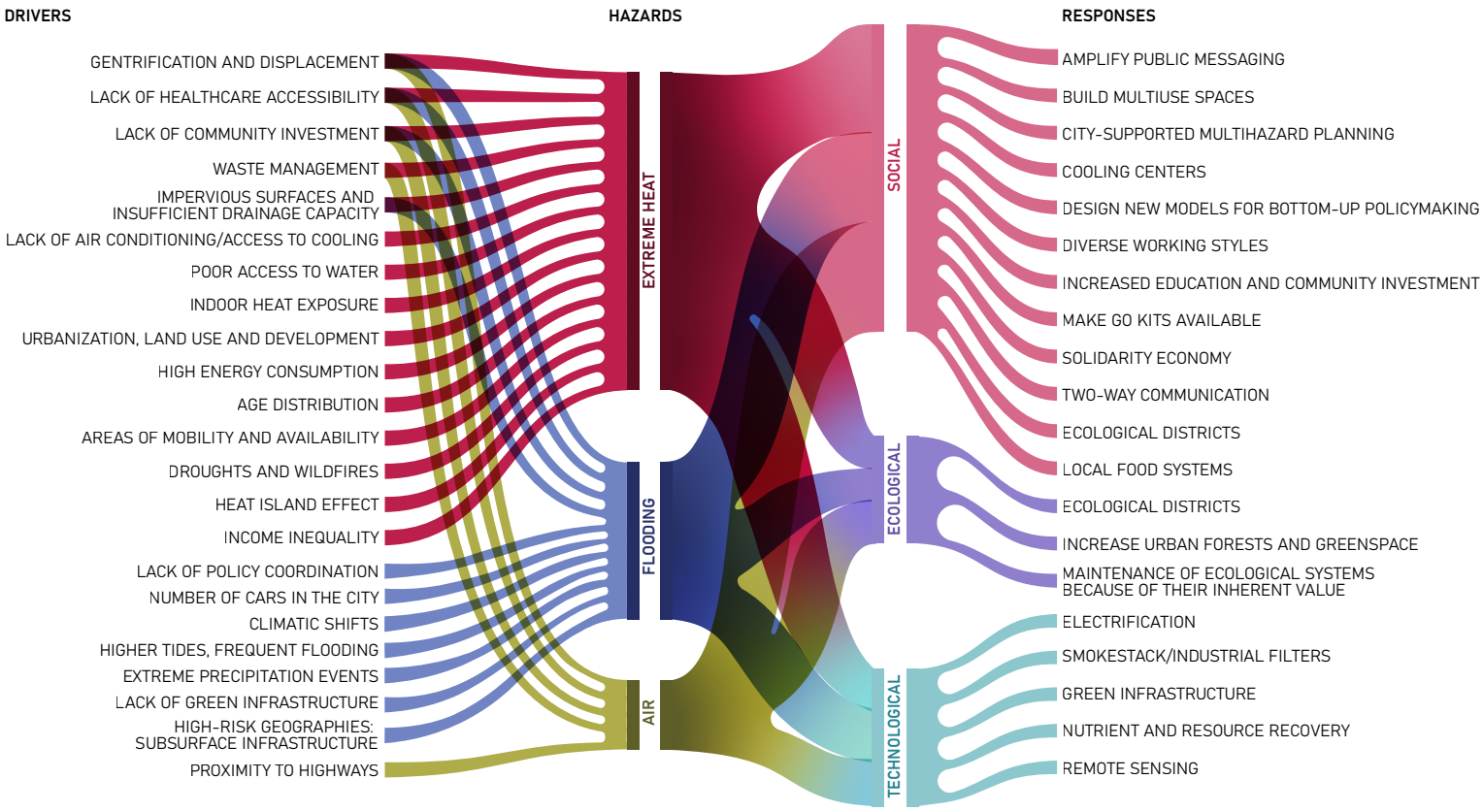
In this session, workshop participants discussed the main drivers of flooding, extreme heat, and poor air quality in New York City, focusing on how the impacts are distributed and experienced across the city. They worked in five small groups: two focused on floods, two on heat, and one on air quality. They were asked to conceptualize a driver of these hazards as a condition or phenomenon that increases exposure to a hazard or worsens the risk or severity of the hazard. Figure 1 provides an overview of all the key drivers identified, along with potential social, ecological, and technological responses. Notably, climate change is associated with only a few of the drivers of these three hazards, and some drivers exacerbate multiple hazards. For example, inadequate community investment was identified as a driver of all three hazards.

Flooding

The workshop participants highlighted a number of critical drivers of flooding—especially infrastructure, which many said exacerbates flooding risks. Both flooding groups emphasized that impervious surfaces and insufficient drainage capacity act as major drivers of flooding across the entire city. Participants spent a great deal of time discussing the importance of timely and effective infrastructure maintenance, noting that preventative maintenance needs to be improved.

Across both groups, there was consensus that aging infrastructure and inadequate funding for routine maintenance is a major impediment to preparedness. Catch basin maintenance was frequently cited as an example of how improper maintenance acts as a driver of city flooding. Participants highlighted that deferred maintenance is often closely tied to issues of funding, and that securing adequate capital for infrastructure installation, improvements, and repairs poses a significant challenge for the public agencies responsible as well as for residents and community groups.

Figure 1 - **Drivers of, and Responses to, Three Major Climate Change Hazards**



∗ For the purposes of this graphic, a driver is "a condition or phenomenon that increases the exposure, risk, or severity of the hazard."

Image credit: Rose Zhang

In addition to city infrastructure, housing was a major topic of discussions. Of particular concern for all the participants is the lack of safe and affordable housing. According to the municipal representatives in attendance, the city's current housing stock does not meet the needs of mobility-impaired residents. This, in turn, forces people to live in places where they are exposed to flood risks (i.e., low lying neighborhoods and basement units).

The unpredictable nature of extreme precipitation events was also cited as a driver of flood risks. In both the session discussions and during the presentation by Dr. Ortiz, it was made clear that providing accurate and timely models for extreme weather events is challenging, especially at the neighborhood scale. This means that it is difficult to anticipate where extreme rainfall will occur, and this, combined with the complexity of the built environment, makes it difficult to identify which areas of the city are at the highest risk of flooding.

Inequitable access to healthcare facilities and how this interacts with climate change was also mentioned. According to many of the experts in attendance, while NYC has excellent hospitals, residents of lower-income neighborhoods often cannot afford them and may struggle even to get to them. During an emergency such as a severe flood, workshop participants said, people in underserved communities are at higher risk.

Ineffective communication was also cited as a critical driver of flood risk. At the local level, municipal experts noted that previous shifts in stormwater management strategies were not communicated well to the public, which caused frustration and resentment and hindered the successful implementation of those efforts. Workshop participants said there is a need for initiatives to convey information about local climate change impacts. Although there was broad agreement that the government needs to engage in more effective and efficient climate education efforts, how best to achieve this was left as an open question. Overall, participants noted that addressing flooding requires not only physical infrastructure changes, but also a holistic approach that incorporates the socioeconomic drivers of vulnerability in New York City.

Photo 3 - **Workshop attendees discuss the main climate hazard drivers in NYC.**

Image credit: Melanie Chu

Extreme Heat

As with flooding, the groups discussing extreme heat identified several non-climatic drivers of extreme heat risks, with participating experts noting that social vulnerability is associated with heightened exposure to extreme urban heat. Income inequality and other inequities put people in harm's way and limit their ability to adapt and protect themselves from dangerous temperatures.

Like many cities worldwide, New York City experiences the urban heat island effect. Buildings, streets, and other infrastructure absorb solar energy during the day, raising the overall ambient temperature, and release that heat at night, when temperatures in less built-up areas are much cooler. The combustion of fossil fuels for cooking, heating, and transportation was also highlighted as a major contributor to climate change and thus urban heat.

The groups also discussed how social disparities and the deterioration of buildings and air conditioning systems affect how people experience extreme heat when they are indoors. Deferred maintenance and inadequate adaptation efforts, they said, exacerbate heat-related challenges. The discussion brought up broader factors contributing to heat exposure, such as land use patterns and transportation systems. For example, the configuration and focus of a transportation network predicated on automobiles was frequently highlighted as a driver of urban heat.

The discussions also highlighted important and persisting knowledge gaps, such as uncertainties related to the uneven distribution of heat-related hazards; how both geography and socioeconomic factors affect exposure to extreme heat; and how income and resource limitations affect communities' coping capacity.

Further research is required to identify the most effective emergency response measures during heat events and to assess the efficacy of cooling centers (air-conditioned

spaces made available to the public during heat events, such as in libraries, malls, schools, and community and senior centers). A recent report by the NYC Comptroller found these centers are inequitably distributed across the city. Many participants specifically noted the need to identify barriers to accessing cooling resources, and to quantify the potential that greening initiatives can have on urban heat mitigation.

A key takeaway was that these challenges are complex and require transdisciplinary responses. Participants noted the importance of collaboration across sectors to develop effective strategies for heat mitigation and resilience-building, but also the logistical, financial, and political challenges associated with the formation and sustainability of these coalitions.

Air Quality

This session began with a discussion about what constitutes "good" versus "bad" air quality. The initial part of the group's input focused on the wildfires from Canada that impacted New York City's air quality in the summer of 2023. It was clear that this incident had a lasting impact: participants from the community said the smoke, smell, and orange hue in the sky had left city residents more aware of, and concerned about, air quality issues. Table 2 summarizes the indicators of air quality identified during the discussion.

Next, the conversation turned to drivers/sources of air pollution and poor air quality. All the participants agreed that the combustion of fossil fuels is a major contributor to poor air quality in New York City. They specifically mentioned fuel used to cook and heat homes, fuel burned to power internal combustion engines, and fuel burned to power industrial plants as major sources of air pollution.

Building on this discussion, two municipal air quality experts spoke about the need to focus not only on outdoor air quality, but also on indoor air quality, which is a major public health concern. A key source of pollution is gas from stoves and other appliances; another common problem in poor-quality housing is the presence of mold and/or asbestos and dangerous volatile organic compounds (VOCs). The experts also explained that weather conditions can affect indoor air quality. For example, high humidity and heat can increase the risk of formaldehyde off-gassing, a condition that can result in negative health outcomes. This example clearly indicates the need to understand the complex relationships between seemingly disparate hazards and to be positioned to quantify the compounding nature of these issues.

Another major source of air pollution mentioned repeatedly was waste. The participants highlighted that poor waste management, both within neighborhoods of the city, as well as at waste treatment plants, is a key source of air pollution. The municipal experts participating in the session noted that solid waste produced by New York City is taken to landfills in New Jersey, but emissions from those landfills (i.e. methane from organic waste) still contribute to poor air quality in the city—as well as to overall greenhouse gas emissions.

Industrial sites were also a major focus of the discussion. A Brownsville resident noted that he lives close to many factories/industrial sites and that this contributes to poor air quality in the neighborhood. Building on this community insight, participating municipal experts noted that power plants used to meet peak demand, which typically rely on fossil fuels, are often situated in lower-income neighborhoods.

Although the majority of the discussion focused on local sources of air pollution, municipal experts in the group also noted that larger regional/global processes also impact air quality in the city. Weather patterns, atmospheric currents, sunny days that contribute to the production of ozone (O3), and smoke from distant wildfires—as with the Canadian fires—were all mentioned as impacting local air quality.

Table 2 - **Various Indicators Used To Determine Air Quality**

Communities' indicators of good air quality	Communities' indicators of poor air quality	Experts' indicators of good air quality	Experts' indicators of poor air quality
Fresh air	Poor visibility	No offensive odor	Offensive odor
Blue skies	Orange hue	Low concentrations of PM2.5 and PM10	High concentrations of PM2.5 and PM10
Scents from nature	Bad smell/odor	Low nitrogen oxide (NOx) levels	High nitrogen oxide (NOx) levels
Rain smells	Inhaling bad things	Low ozone (O3) levels	High ozone (O3) levels
Good visibility			

SESSION 2: CLIMATE RISKS, VULNERABILITIES, AND EQUITY

EXERCISE FORMAT & DESCRIPTION

This session focused on pinpointing key climate risks and vulnerabilities associated with flooding, extreme heat, and air pollution in New York City. Participants discussed the actions and responses that are already being implemented to address these growing risks, with particular attention to the most underserved populations. Following this, the experts highlighted key knowledge gaps, barriers, and challenges, highlighting how the proposed CIVIC-UARC, as a center for transdisciplinary climate adaptation work, could support ongoing efforts to address these issues.

Flooding

This discussion began with an overview of the different climatic drivers of flood risks in New York City: sea-level rise, coastal flooding, and extreme rainfall events — all of which are being exacerbated by climate change. The extent to which people are exposed and vulnerable to flood risks, in turn, depends to a great extent on socioeconomic factors and other underlying issues.

KEY RISKS & VULNERABILITIES

Participants expressed particular concern about the safety of mobility-impaired citizens during flood events. Lack of knowledge and ineffective communication came up again and again as a source of social vulnerability as well. For example, participants said that newcomers to the city, including immigrants, often are unaware of which areas are prone to flooding, and are unable to make informed decisions about whether they want to accept these risks when choosing where to live.

In addition, specific issues associated with the built environment came up multiple times. In particular, experts noted that people living in below-ground apartments and subway riders are at particular risk during floods.

Photo 4 - **Workshop participants discuss existing climate hazard actions and responses in NYC.**

Image credit: Melanie Chu

EXISTING ACTIONS AND RESPONSES

The municipal experts in attendance provided great insight into the work being done across NYC to adapt to increasingly severe flooding events. To begin, they highlighted flood mitigation commitments outlined in the PlaNYC documents. Led by the Mayor's Office of Climate and Environmental Justice (MOCEJ), explicit strategies laid out in the PlaNYC document include the following:

- Create a new leadership structure for coastal flood resilience in 2023, headed by the Department of Environmental Protection.
- Implement a multilayered strategy for flood resilience.
- Launch a voluntary housing mobility and land acquisition program to provide housing counseling and facilitate future land acquisition with federal and state funds.

Experts from MOCEJ also discussed the Climate Strong Communities program, which Mayor Eric Adams has said will boost climate resilience across the city, "especially in high need areas that face deeper impacts as a result of climate change" (Mayor's Office of Climate & Environmental Justice, n.d.). Officials are also incorporating the latest climate information into infrastructure planning and retrofitting efforts, and they are working proactively through interagency coordination and specialized task forces.

Participants mentioned that the City is contributing to the Hazard Mitigation Plan, East Side Coastal Resiliency Project, and Department of Environmental Protection (DEP) Bureau of Coastal Resilience. The Department of City Planning (DCP) is trying to bolster neighborhood planning initiatives to increase climate resilience in coastal neighborhoods such as Jamaica Bay, Coney Island, and Long Island City. Extensive investments in wetland restoration projects were also mentioned, such as the Blue Belts program, a collaborative effort between the DEP and the Department of Parks and Recreation (NYC Parks). Through the construction, preservation, and maintenance of streams, ponds, and wetlands, this work aims to reduce urban flood risks while contributing to biodiversity. Additional green infrastructure initiatives such as the Tibbetts Brook Daylighting Project, an effort led by the DEP, are working to reduce the incidence of combined sewer overflows.

Both academic and municipal experts also mentioned FloodNet, a partnership between researchers from across the city and several municipal agencies, including the MOCEJ, DEP, and Office of Technology and Innovation (OTI). This transdisciplinary project, which began in 2020, is in the process of installing and maintaining 500 flood sensors across the city. These sensors will enhance real-time data collection capacities that will provide municipal agencies and community actors with the knowledge necessary to make informed decisions during flooding events.

Public-private partnerships are also addressing flood risks. Rainproof NYC, for example, brings together a number of municipal offices and the private firms Rebuild by Design and One Architecture & Urbanism.

Workshop participants said communities are actively engaged in collaborative efforts to address flood risks and enhance resilience, such as by monitoring flood events across the city. The municipal experts noted that these "citizen science" efforts not only generate valuable data, but also strengthen community resilience by building solidarity and support networks among residents. The community engagement efforts of the U.S. Army Corps of Engineers were mentioned as well.

KNOWLEDGE GAPS, BARRIERS, AND CHALLENGES

Both flooding groups focused on the challenge of predicting, in an accurate and timely manner, exactly where extreme rainfall events will have the most significant impact. Mr. Herreros Cantis, who is working to develop a new flood map for the city, further highlighted the heterogeneous nature of flood risks in NYC.

Funding

Inadequate funding was mentioned throughout the discussion as a barrier to flood risk mitigation. Participants made it clear that this is a chronic challenge due to competing demands on the city budget and stressed the need for capital spending to be efficient and matched with adequate financial resources to support maintenance, prioritizing the areas of greatest need. According to many of the participants, the city's demographics are changing rapidly (the increasing age of the population was noted frequently), and future climate planning will need to take this into account. Similarly, the adoption of

more responsive, flexible, and perhaps even novel zoning designations will likely need to be considered. Participants stressed that future land use plans will need to include strategic retreat as an option in some areas.

Communication

The historic and ongoing struggle to establish and maintain effective communication between municipal agencies and community actors came up frequently. The participating municipal experts noted that, while tools such as NYC311, a non-emergency phone line that connects residents to city services and information, have dramatically improved community input and feedback, there are still significant challenges in communicating clearly and effectively with citizens.

The historic and ongoing struggle to establish and maintain effective communication between municipal agencies and community actors came up frequently. While tools such as NYC311 have dramatically improved community input and feedback, there are still significant challenges in communicating clearly and effectively with citizens.

Extreme Heat

Like flood risks, exposure to extreme heat and the urban heat island effect varies across New York City, reflecting differences in the built environment, tree canopy, and green space, among other factors, as well as proximity to the coast. Rising temperatures and extreme heat risks affect all New Yorkers to some extent, but the two groups focused on heat highlighted the inequitable distribution of those risks.

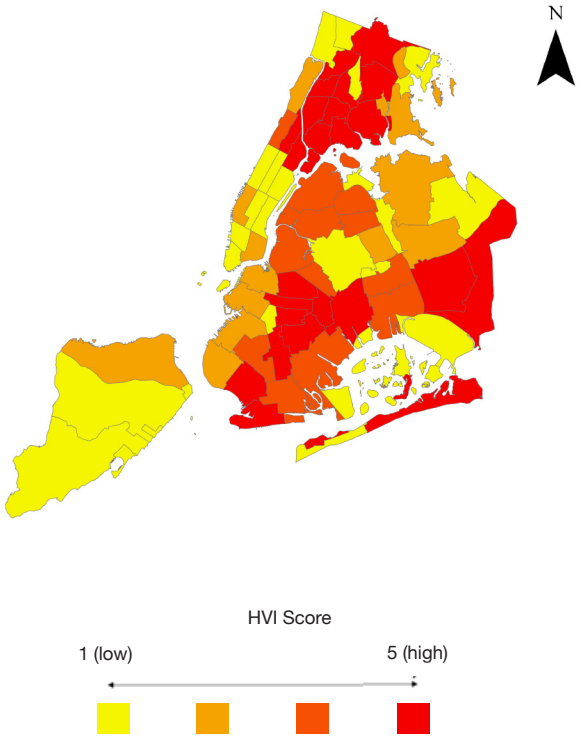
EXISTING ACTIONS AND RESPONSES

The experts also made it clear that the City is engaging in a wide range of efforts to combat this issue. For example, since 2017, municipal greening projects have added thousands of street trees in the most heat-vulnerable neighborhoods. Programs to increase the albedo potential of the built environment were also frequently mentioned. In particular, the NYC CoolRoofs effort, initiated in 2009, aims to modify a million square feet of rooftops every year to increase their albedo (that is, their ability to reflect solar energy, instead of absorbing it and exacerbating the urban heat island effect). In addition, the city is providing financial assistance to cost-burdened households so they can buy air conditioners.

KEY RISKS & VULNERABILITIES

NYC's Heat Vulnerability Index (Figure 2) shows how greatly heat vulnerability varies across the city, with some of the poorest neighborhoods facing particularly severe risks. Experts highlighted the need to better understand the drivers of vulnerability to heat. They pointed to factors such as income level, the age distribution of the population, land use types, and inequitable access to necessities such as affordable housing.

Figure 2 - **Heat Vulnerability Index for NYC**



KNOWLEDGE GAPS, BARRIERS, AND CHALLENGES

Both groups distinguished between near-term and long-term needs. For example, participants noted that the population is aging, which will increase vulnerability to extreme heat, but existing policies do not account for this trend. Similarly, social issues such as income inequality and inadequate access to housing and cooling equipment were cited multiple times as barriers to adaptation. Policy coordination was cited as a critical area for improvement, with workshop participants emphasizing the need to bridge institutional disconnects. Targeted initiatives such as cooling centers and outdoor misters that can offer temporary relief were highlighted as possible adaptation measures, but these services are often not easily accessible by all community members. Lastly, participants highlighted the need to avoid funding cuts to essential community resources such as libraries, which serve as vital cooling spaces.

For sustainable and effective long-term adaptation to worsening urban heat, the participants stressed the importance of affordable high-quality housing. Gentrification and substandard housing were highlighted as key sources of vulnerability to urban heat. Several experts highlighted the unintended consequences of municipal adaptation efforts such as green infrastructure projects, which can lead to the displacement of cost-burdened households.

Five key questions and knowledge gaps were identified by the two groups:

- What are good proxies and indicators for a heat vulnerability index?
- How do demographic changes, particularly age distribution, impact vulnerability to extreme heat?
- What role does housing access, including legacies of redlining, play in exacerbating heat vulnerability?
- How can policy coordination and budget priorities influence vulnerability to extreme heat events?
- What are the definitions and priorities of environmental justice in the context of heat vulnerability?

Air Quality

On the issue of air quality and environmental justice, representatives from the community discussed how property prices are directly influenced by proximity to power plants and industrial sites. Property near these sites is less desirable and is thus more affordable than in residential areas with cleaner air.

KEY RISKS & VULNERABILITIES

Less-wealthy residents often end up living close to industrial sites. Community members spoke at length about their experiences with environmental injustice, noting the links between industrial air pollution and various respiratory problems and other chronic conditions. People in these areas also struggle to access quality and affordable healthcare, which can lead to a spiral of worsening health outcomes.

EXISTING ACTIONS AND RESPONSES

Asked about the community's response to this dynamic, community members said that activism to address this injustice is ongoing across the city. However, they stressed that neighborhood activism, while critical, is insufficient; higher-level support and engagement by relevant institutions is key. Participating municipal representatives agreed; the consensus was that action is needed at every scale, from individuals, to communities, to the City.

KNOWLEDGE GAPS, BARRIERS, AND CHALLENGES

Knowledge gaps were a key focus of this session. Municipal experts said the science around the drivers of air quality are well understood, but more knowledge is needed about effective solutions that could address this issue effectively and fairly. For example, mandating filters and scrubbers on power plants and industrial sites should help, but the efficacy and cost of some of these technologies is still unclear. Electrification came up multiple times as a promising solution for reducing indoor air pollution from gas stoves and other appliances. Electric vehicles could reduce transportation-related air pollution, and a shift to clearer electricity sources could reduce both greenhouse gas emissions and pollution.

One issue on which there was disagreement within the group was the importance of lifestyle changes. Several people said Americans are profligate consumers, and New Yorkers need to consume less. This led to a somewhat tense

exchange about who decides what is an appropriate level of consumption.

As with the flooding and heat groups, the challenge of effective communication came up again and again in the air quality discussions. Community members said the city does not communicate well with them. In response, municipal representatives highlighted initiatives such as the 311 system. Building on this discussion, the team identified key components of an equity framework for better communication:

» Agreed-upon vision and shared values between the community and the city.
» Engage in robust science: quantify what needs to be quantified.
» Share the results of the science in a timely and accessible manner; establish language that is not intimidating and is accessible by all.
» Give space/time/resources for feedback and dialogue between residents and the City.

Photo 6 - **Workshop attendees discuss knowledge gaps, barriers and challenges regarding air quality.**

Image credit: Melanie Chu

SESSION 3: COMPOUND HAZARDS, CASCADING IMPACTS, AND MULTIHAZARD CLIMATE SOLUTIONS

EXERCISE FORMAT & DESCRIPTION

Urban infrastructure is closely interconnected, which can amplify the impacts of climate hazards. A flood at a subway station can disrupt service on multiple lines, well beyond the site of the flood; extreme heat can lead to power outages and thereby disrupt digital networks and operations that depend on them. In this session, participants discussed such cascading impacts, compound hazards, and the kinds of solutions needed to address them effectively, both in the near term and in the long term. They also examined how different people might be affected, and how to overcome barriers to novel and equitable solutions.

Photo 5 - **Timon McPhearson moderates Session 3.**

Image credit: Melanie Chu

Flooding

The discussion of flooding highlighted several critical concerns, including the confluence of heat waves and floods. The impacts of saltwater intrusion and long-term contamination due to sewer overflows were also highlighted. In addition, participants noted the cascading effects of socioeconomic factors, such as job losses, disruptions in children's education, loss of savings, and increased homelessness. Green gentrification and lack of access to necessities such as food were highlighted as sources of vulnerability.

According to the participants, financial and political constraints pose significant barriers to progress in addressing flood impacts and other environmental challenges. Key barriers identified were power dynamics and the limited number of entities capable of accessing funds to address these challenges. The conversation led to hotspot mapping of overlapping hazards such as extreme heat and floods, highlighting the complexity of mitigating multiple risks. Underlying socioeconomic issues such as migration and food insecurity were pointed to as factors that further exacerbate vulnerabilities across hazards.

Furthermore, the participants stated that inadequate waste management systems and governance complexities increase the potential for harm from flooding. Civic engagement and improved communication were cited as vital to overcoming these barriers, alongside streamlined decision-making processes and enhanced community involvement. Community members explained that despite extensive data collection for policy formulation, there is often a disconnect between data gathering and meaningful community engagement, leaving residents without clear endpoints for their involvement. They added that the prevalence of silos between various stakeholders and sectors further impedes progress, highlighting the need for improved communication channels and policies to address these divisions.

The discussion on flooding mitigation and adaptation measures encompassed a wide range of strategies aimed at both short-term recovery and long-term planning. Prioritization of funding for high-risk zones for flood management and integrated local planning were highlighted as crucial steps for effective and equitable action.

During the discussion on near-term solutions, participants mentioned that in order to recover quickly after a flood, it is important to correctly identify the impacted areas for immediate relief efforts and ensure access to healthcare. Strengthening interjurisdictional communication and neighborhood level organizing was put forth as crucial for short-term resilience. Several nature-based solutions were mentioned, such as planting trees, reducing the extent of paved surfaces, water retention efforts (i.e. bioswales and rain gardens), and revitalization of natural areas. Redesigning the built environment to eliminate basements was also highlighted, as below-ground spaces are very dangerous during floods.

More solutions discussed at the local level included diversifying food sources, composting, and capturing stormwater upstream at a district level to offer proactive flood risk mitigation and resource management. Further infrastructure and regulation implementation issues addressed the need for updated regulatory frameworks, such as codifying flood solutions into law for environmental sustainability. Community members mentioned ensuring green jobs within underserved communities and establishing resource hubs with diverse functions to meet community needs.

Extreme Heat

Participants emphasized the correlation between heat waves and air quality, as well as the compounding effects of blackouts and flooding. The discussion also touched upon the challenge of maintaining air quality while cooling buildings during heat waves, especially when keeping windows open. Furthermore, the variability in the locations of cooling centers was highlighted as an area requiring attention and improvement to ensure accessibility during heat waves.

Several critical knowledge gaps were identified during the discussion. The need for more effective, timely, and accessible communication came up repeatedly. The impact of politics on emergency response and the utilization of emergency response technologies such as Everbridge and data mining tools (Data Miner, DH4) were also noted. However, according to the participants, staff limitations pose challenges to risk management and continuity, while effective communication of risks and the equitable distribution of resources remain pivotal concerns. Better understanding of cross-cutting issues across agencies and sectors was noted as essential for comprehensive emergency management. The importance of the Department of Emergency Management was discussed, with experts stating the importance of this institution in coordinating responses to various crises.

Compound and cascading risks were also discussed—for example, participants noted that during times of extreme heat, the electrical grid is at increased risk of failure. When this happens, residents cannot cool their homes, which makes them more vulnerable to the heat. Another example cited was opening windows to stay cool during very hot days, when air quality can be particularly poor.

Participants noted that New Yorkers can learn from how people in other countries manage heat. They also noted the need for systems-level behavior changes, such as promoting corporate and government accountability for energy conservation measures like turning off lights in buildings when not in use. It is also important to advocate for more effective and equitable decision-making processes in addressing heat-related issues, they said. Investing in the creation of urban forests and green spaces came up as a key solution to not only mitigate heat, but also positively impact mental health and overall well-being.

Key Solutions

Participants identified several potential solutions:

- **Public Messaging and Awareness:** Emphasis on the importance of public messaging and awareness campaigns to educate individuals about cooling centers, emergency response teams, and other resources available during extreme heat events. There was a discussion about whether notification systems such as Notify NYC should have an opt-out or mandated registration system to ensure broader coverage and effectiveness in reaching vulnerable populations. Basement owners should be considered a particularly at-risk group.
- **Community Engagement and Education:** Individual education and community engagement in preparing for and responding to heat emergencies. Initiatives such as CERT (Community Emergency Response Team) and ReadyNY aim to empower communities to take proactive measures.
- **Utilization of Cooling Centers:** The utilization of cooling centers should be supported, whether through public facilities such as libraries and recreation centers or through online platforms such as Notify NYC, which provides information on the location of cooling centers. Cooling stations need to be identified separately from a cooling center.
- **Green Infrastructure and Urban Planning:** There was a shared emphasis on green infrastructure solutions such as green roofs and increasing urban forest and green spaces to mitigate the heat island effect and improve mental health. The idea of reclaiming streets for green spaces was also mentioned as a long-term urban planning solution.
- **Agile Planning and Capacity Building:** Making working styles more flexible to accommodate schedules during extreme heat events and increasing workforce capacity through additional training and knowledge dissemination. The implementation of agile planning cycles and agile responses across agencies is recognized as an effective approach to addressing evolving challenges and testing solutions iteratively.
- **Drills, Infrastructure Response:** The efficacy of running drills and refining emergency response protocols was mentioned, but there is also a question about whether the infrastructure can keep up with the evolving challenges posed by extreme heat events. There was a proposal for conducting greater NYC simulation exercises to test the readiness and resilience of infrastructure, emergency response teams, and communities in the face of extreme heat events and other cascading hazards.
- **Emergency Management Efforts:** The appointment of emergency management directors for each mode of transport was mentioned, in order to enable swift deployment of resources in the event of disruptions, bolstered by technology integration.
- **Weather Severity Tool:** The development of a weather severity tool was recommended for further contribution to the city's preparedness and resilience efforts.
- **Mobilizing Existing Indices/Technology:** The discussion touched upon the need to measure specific heat indices to assess their severity and utilization of Urban Risk Index—inspired by FEMA risk index (vulnerability including infrastructure), tailored to NYC DOH's Heat Vulnerability and Flood Vulnerability indices to help to map and prioritize investments.

Air Quality

The group highlighted compounding air quality hazards as a key knowledge gap. The top challenges associated with this topic included:

- Knowledge gaps associated with the quantification of cascading air quality hazards.
- Local vs. global drivers of poor air quality—some drivers can be addressed locally, while others are global and require new governance structures.
- Prioritization: how to prioritize short-term vs. long-term issues.

The air quality group also discussed ways to develop multi-hazard solutions or solutions that can create synergies across multiple climate responses. The group started with one problem/solution—how to reduce congestion in the city. From there, the group brainstormed solutions that would simultaneously alleviate this problem while also generating more widespread benefits. In summary, CIVIC-UARC has strong air quality partners in the public sector, but the project is still searching for strong researchers and subject area experts to join the team.

NEXT STEPS

This workshop is one step in the foundation of the new Civic-Led Urban Adaptation Research Center.
Below are next steps in the preparation process:

- Share the workshop report with the workshop participants and other researchers and practitioners working on urban climate adaptation.
- Compare the insights gathered through this workshop with those gathered in the two other workshops, and discuss how to integrate the different perspectives in the forthcoming funding proposal.
- Develop a theory of change that will inform the new Civic-Led Urban Adaptation Research Center.

The team's objective is to create a Center for sustained collaboration to better understand key climate risks and to find just and effective solutions, drawing on the collective knowledge and ideas of a diverse group of researchers, policymakers, industry experts, community advocates, and local residents.

We also will consult the key insights from the two other research workshops and continue to advance and refine our ideas in consultation with the two other research areas.

ABOUT THE AUTHORS

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Image credit: Cornell Mui Ho Center for Cities