CCRUN

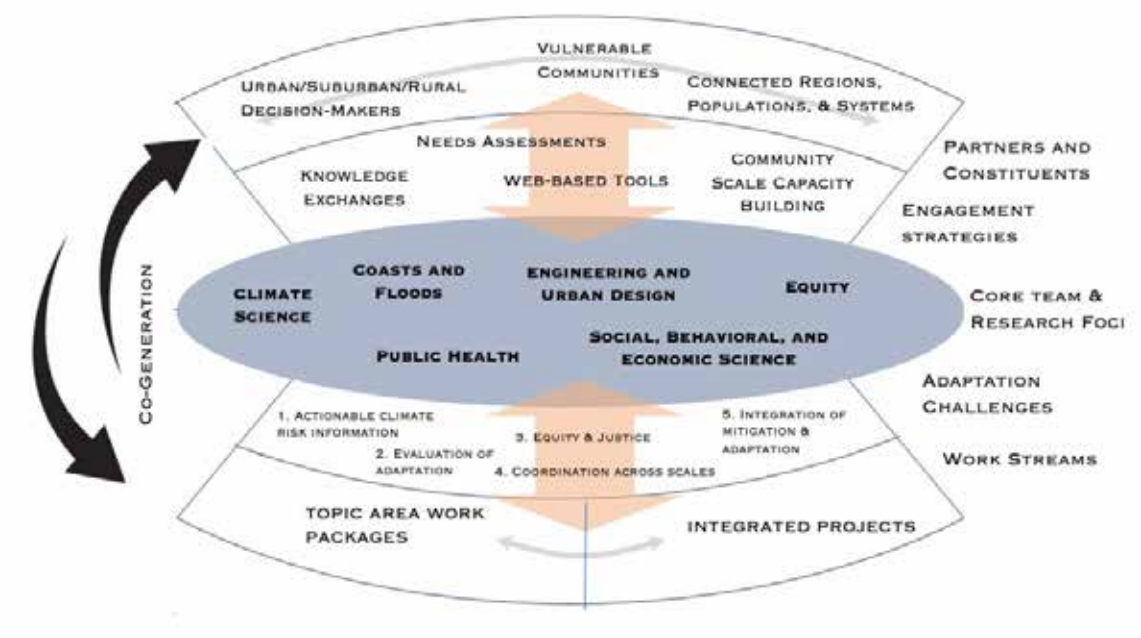
CONSORTIUM FOR CLIMATE RISK IN THE URBAN NORTHEAST

A NOAA CAP TEAM

Supporting Regional Implementation of Integrated Climate Resilience

NA21OAR4310313

Research Highlights,
June 1, 2023 – May 31, 2024



CCRUN Phase III Structure

CCRUN'S MISSION

CCRUN conducts stakeholder-driven research that reduces climate-related vulnerability and advances opportunities for adaptation in the urban Northeast

Cover: Image courtesy of NASA

Columbia University in the City of New York

Stevens Institute of Technology — The Innovation University

Rutgers — The State University of New Jersey

Boston University

Drexel University

Hunter — The City University of New York

THE CCRUN TEAM

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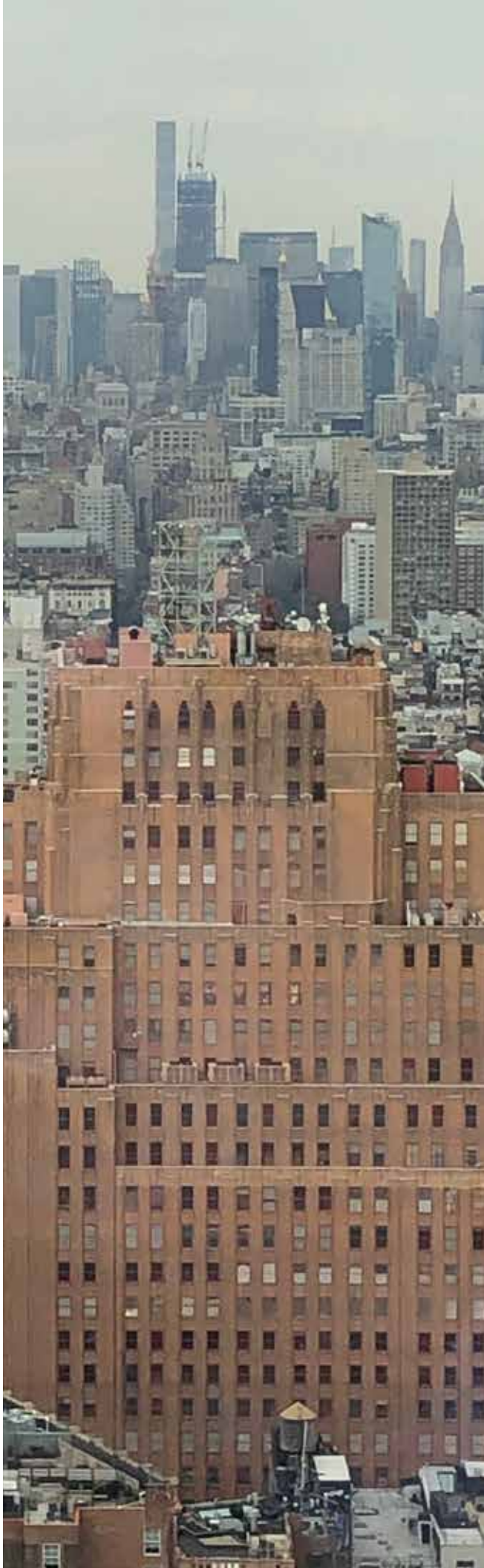
STAKEHOLDERS AND PARTNERS

A Better City**
Camden County Municipal Utilities Authority
Canarsie Community Development Inc.**
City of Boston, Mass**
City of Chelsea, Mass**
City of Camden, New Jersey
Consolidated Edison
Eastwick United
Edgemere Alliance
Empowered CDC
Esperanza
FarmerJawn
FEMA Region 2
Global Thinking Initiatives Inc
Greenroots Groundwork Elizabeth
Groundwork Hudson Valley
Javits Convention Center
LandHealth Institute
Monmouth, NJ County OEM
Monmouth, NJ County Planning Office
Naval Weapons Station Earle
New Jersey Business and Industry Association
New Jersey Chamber of Commerce
New Jersey Sea Grant
New York City Department of City Planning
New York City Department of Environmental Protection
New York City Mayor's Office of Climate and Environmental Justice
New York City Emergency Management**
New York Hall of Science
New York Sea Grant
New York State Department of Environmental Conservation
New York State Department of Public Service
New York State Energy Research and Development Authority
NJ Small Business Development Center
Pamunkey Nation**
Philadelphia Office of Sustainability
Philadelphia Water Department
Point Breeze Community Network Plus
Port Authority of New York and New Jersey
Port Richmond Strong
Residents Organized for Advocacy and Direction
Rockaway Initiative for Sustainability and Equity
Rosedale Civic Association**
Shinnecock Indian Nation**
Town of Brookhaven, New York**
University City District

** Indicates a new stakeholder CCRUN started working with over the reporting period.



KEY ACCOMPLISHMENTS

CCRUNs interdisciplinary research team has expertise spanning the fields of climate and physical science, urban design and engineering, and the social sciences. This enables the team to effectively address the many challenges facing the urban population centers of the northeast and the communities within, through cutting-edge stakeholder driven research.

The New York City Climate Change Vulnerability, Impacts, and Adaptation Study (VIA), which culminated with the release of a final report in April 2024, was a multi-year project working with the Mayor's Office of Climate and Environmental Justice (MOCEJ) to assess future climate change and its potential impacts, to inform decision-making by the City of New York. It explores how current and future weather and climate may pose significant challenges to the city's infrastructure and communities. The report also provides information that could help advance solutions for adaptation and resilience.

Given their experience working on similar assessments and established relationships with stakeholders in New York City, CCRUN played an important role on the VIA project team, with multiple CCRUN team members leading individual tasks of the study. Presented here are each of these tasks, with a brief description and connection to CAP/RISA program theory where applicable. Additional information on the research and key findings can be found in other sections of this report.

Task 2 - Climate Projections and Climate-Sensitive Hazards for New York City Region
Lead-PI Horton updated sea level rise projections for New York City and investigated compound extreme events (e.g., heat and humidity; sequences of heavy rainfall and heat). Co-PI Orton led research that quantified the joint probabilities of storm surge and rainfall and studied the influence of storm type on compound flooding (Chen et al. 2024; Rosenzweig et al. 2024). They also examined the potential underestimation of tail risk when performing extreme value analysis on mixed storm types, due to the larger importance of tropical cyclones for extremes (Ortiz et al. 2024). The results of Task 2 expanded the scientific data **assets** available to the City of New York to evaluate future climate risks.

Task 3 - Current and Future Extreme Heavy Rainfall in New York City
Co-PI Montalto used a literature review, expert elicitation methods, analyses of historical and future climatological data, and historical databases and media reports to explore why, how, and with what impacts precipitation has, is, and will continue to change in New York City. Researchers developed future IDF curves for the city and used hydrologic and hydraulic modeling to explore the implications of these changes and other rainfall characteristics on pluvial flooding.

Task 5 Flood Vulnerability Index for New York City
Co-PI Madajewicz developed a Flood Vulnerability Index for the City of New York, in order to identify the most vulnerable populations and to guide the City's efforts to reduce vulnerability to flooding in an equitable manner across the City's neighborhoods. The index built on prior CCRUN-supported research that identified indicators of vulnerability, which are specifically relevant to flooding. The index has added to the **assets** available to the City of New York to advance resilience to flooding

with attention to equity. **Learning** and **sense of agency** at city agencies advanced through discussions between the research team and key stakeholders regarding effective ways of applying the index to decisions.

Although this research partnered with the largest city in the urban northeast, the majority of the findings will likely have their greatest impact at the neighborhood scale. An extensive network of stakeholders (many familiar with CCRUN) participated in and informed the project, including the City's Inter-Agency Climate Adaptation Task Force (ICAT). The VIA project offers a model of co-producing science for decision-making, with potential transferability to other municipalities in the urban Northeast.

Participation in the VIA project also tied directly to the research questions/challenges guiding CCRUN's Phase III work. Specifically, the work on the project advanced:

The need for the development and communication with diverse audiences of actionable information on more nuanced and complex climate risks: The City's ICAT team participated in the individual task team meetings, to ensure that the information was relevant to their needs. The report is available (for free) online and was written for general audiences. The Flood Vulnerability Index is also available as an interactive online application, which allows users to explore different dimensions of vulnerability.

The need to fully embed consideration of equity and justice into climate risk assessments and adaptation efforts: The Flood Vulnerability Index enables city agencies to identify how vulnerability and its various dimensions differ across different neighborhoods and populations in the city, thereby enabling the city to prioritize investments in reducing vulnerability. The index can inform the type of support that may reduce vulnerability based on values of different indicators.

The need for coordination across scales: The sea level rise projections were developed in consultation with New York State's Climate Impacts Assessment. The VIA project held a workshop with City (and State) representatives to make sure the methods were consistent across efforts in this project; such coordination is essential, as infrastructure networks span spatial scales and jurisdictions

Cover of the New York City Climate Change Vulnerability, Impacts, and Adaptation Study (VIA) Final Report, released in April, 2024.

NEW AREAS OF FOCUS AND PARTNERSHIPS

Academic Network to Support Urban Water Resilience (ANSUWR)

CCRUN (Co-PI Montalto) expanded our partnership with local stakeholders including the Philadelphia Water Department (PWD) and the Office of Sustainability (OOS), as well as University of Pennsylvania and Villanova University, to continue with our established Academic Network to Support Urban Water Resilience (ANSUWR). Inspired by CCRUN's model of stakeholder-driven research, ANSUWR is a platform through which community organizations can access university researchers and scientific knowledge as they pursue resilience measures.

The team received pilot funding from the William Penn Foundation to issue RFPs to which community-based organizations can propose projects for academic teams to undertake that address flood mitigation, cloudburst management, water quality improvement, and interrelated land use, vegetation canopy, infrastructure, and climatic conditions. Through a guided process, ANSUWR brings together the extensive industry knowledge, applied research, service learning, design, and stakeholder engagement activities of three local universities (Drexel, University of Pennsylvania, and Villanova) to address this multifaceted problem.

This partnership has been established to harness the work completed by students at these universities and implement them to solve real-world problems throughout the city. During the reporting period, the team piloted ANSUWR by partnering with local non-profit, FarmerJawn, an organization dedicated to reintroducing farming into the lifestyles of urban people to cultivate physical, social, and environmental health. FarmerJawn is made up of two entities: FarmerJawn Farming & Retail, which is for-profit, and FarmerJawn & Friends Foundation, which is non-profit (501c3). FarmerJawn works to achieve their mission by operating in three main focus areas: 1) School-Based Programming that bridges the gap between agriculture and younger generations, 2) "Agripreneur" Training Program: Agricultural training for minority groups, and 3) CornerJawn: A new concept for the traditional urban corner store.

Co-developing a decision support framework for adaptation to coastal flooding: A comparative case study of communities in New York and Virginia

Co-PI Madajewicz, in collaboration with Co-PI Orton and Dr. Molly Mitchell from the MARISA CAP, have begun new partnerships this year with several communities including the Shinnecock Nation and Mastic Beach on Long Island, NY and the Pamunkey Nation in Virginia. This work is being funded through a new NOAA BIL grant. The objective of the partnerships is twofold. First, the researchers will co-develop a flood adaptation plan in each community that is based on the science needed for a strong funding application. Second, the comparative study of the adaptation planning process across the different conditions encountered in two communities on Long Island and two in coastal Virginia will result in a flood adaptation decision framework that should be applicable across the broader northern and middle Atlantic coastal region and potentially beyond. The decision framework will consist of a flood vulnerability assessment that integrates science and local knowledge using mental modeling, an analysis of trade-offs between different adaptation pathways using agent-based models informed by the mental models, and a participatory ranking approach to selecting the final adaptation plan. The intent of the framework is to assist other communities with developing adaptation plans.

Building Collaboration with US Geological Survey

In CCRUN's research (Co-PI Orton) on post-tropical cyclone Ida's impacts on New York City, the team is partnering with and funded by the US Geological Survey (USGS). The research develops a coastal flood model that can incorporate pluvial/rain forcing. The partnership is valuable for the opportunity to learn from the model developer and a leader in the field of modeling coastal hazards, John Warner (USGS). CCRUN has also collaborated with New York City Emergency Management, who is helping map the flood depths from Ida, as well as counterfactual scenarios that assess the potential differences in the flooding within small spatial and temporal shifts to the storm. The Coupled Ocean-Atmosphere-Wave-Sediment Transport (COAWST) model is a community, open-source model and has a very wide global user base, which is useful in educational efforts as well as for having access to contributions from its broad user community. This research will improve risk and climate impact assessment capabilities at Stevens and more broadly across the COAWST user base.

Improving Engagement Methods for Coastal Resilience and Reducing Climate Risk: Bridging Learning Networks from the Urban Northeast (CCRUN) to the US Caribbean (CCAN)

During this reporting period CCRUN began a partnership with the NOAA CAP/RISA Caribbean Climate Adaptation Network (CCAN) team through a Bipartisan Infrastructure Law (BIL) project, "Improving Engagement Methods for Coastal Resilience and Reducing Climate Risk: Bridging Learning Networks from the Urban Northeast (CCRUN) to the US Caribbean (CCAN)". This project seeks to implement, compare, and evaluate the transferability of existing methods of community engagement and approaches for integrating social and interdisciplinary knowledge into climate adaptation planning for coastal flooding. The project team has already hosted one joint CCRUN/CCAN workshop to develop a common knowledge base and understanding of community engagement approaches used across both teams. The overarching goal of this project is to create a methodology for comparing, assessing, evaluating, and measuring participant experiences, processes, and outcomes, and then to apply these methods in 4 selected frontline communities in the United States Virgin Islands and Puerto Rico.

Temperature Monitoring in Boston, MA

CCRUN Public Health team researchers (Co-PI Fabian) are partnering with the city of Boston, A Better City and The Boston Foundation to deploy 10 to 15 temperature sensors on private properties owned by ABC member organizations. The plan is to strategically place the sensors in heat island hot spot neighborhoods featured in Boston's 2022 Heat Plan. These locations include Chinatown, Dorchester, East Boston, Mattapan, and Roxbury, as well as Allston-Brighton. Through a temperature sensor pilot, the team will compare National Weather Service temperature observations at Logan Airport (in Boston) with live temperature data from hot spot neighborhoods. The goal of this pilot is to better understand whether the deployment of additional sensor data could be incorporated into more targeted heat emergency declarations and protocols by neighborhood. Finally, in partnering with academic institutions, the data analysis of such a temperature sensor pilot could provide additional educational opportunities for local students and academic partners. This pilot builds upon existing research done by the City of Boston, CCRUN Public Health team, and academic partners, and would help to lay the foundation for future work launching a semi-permanent temperature sensing network in partnership with the City of Boston, paired with a publicly accessible dashboard of temperature sensor data through a website.

KEY RESEARCH FINDINGS

Compound Pluvial-Coastal Flood Modeling

Highlighted as a new partnership, CCRUN (Co-PI Orton) is collaborating with USGS to develop a coastal flood model that can incorporate pluvial/rain forcing. These improvements are applied in a simulation of flooding by post-tropical cyclone Ida in the Jamaica Bay watershed of New York City. Outcomes of the research include the first spatially continuous flood map of Ida, and improvements to our understanding of the flood risks posed by extreme rain events and compound pluvial-coastal events for New York City. The team also studied counterfactual scenarios that assess the potential differences in the flooding within small spatial and temporal shifts to the storm. Results demonstrate that Ida could have been worse due to more rain or compounding by high tides (Kasaei et al., submitted).

Community Climate Resilience Small Grant Program

Following the first year of our pilot Community Climate Resilience (CCR) small grant program, CCRUN Co-PI Robin Leichenko, senior personnel Jeanne Herb and Marjorie Kaplan, graduate student Katherine Cann, and undergraduate researcher Nyla Howell analyzed the initial outcomes of the CCR program to improve our understandings of the program's ability to build opportunities for **learning** and developing a **sense of agency** for community partners and researchers involved in the program. The team's research included an extensive review of academic literature, informal discussions with managers of similar grant programs, and a reflexive analysis of various stages of implementation of the CCR program, which resulted in a set of promising approaches for more equitable engagement, funding, and co-production partnerships between university-based researchers and community-based organizations. The research in this area contributed to CCRUN's Phase III goals of embedding equity and justice into adaptation efforts, and the Equity

Group's target of building inclusive processes for equitable engagement in adaptation. Findings were compiled into several conference presentations and panel discussions, including at Geography2050 in New York City in November 2023, and the National Adaptation Forum in St. Paul in May 2024, and a paper in *Community Science* (in press).

Groundwork Elizabeth is working to restore the banks of the Trotters Branch tributary of the Elizabeth River through community tree planting events with funding support from CCRUN. Photo by Groundwork Elizabeth.

Compound Extreme Events

CCRUN (Lead PI-Horton) focused on sequential relationships between high precipitation and high humid heat, since both types of events are projected to increase with climate change, and because associated infrastructure disruptions and challenges to emergency management can be expected to make the second event in the sequence more impactful than it would otherwise be. The research found that humid heat tends to be above normal in the days leading up to heavy rain. Researchers also found that humid heat rises in the days leading up to heavy, followed by a slight drop after.

Darby-Cobbs Watershed

CCRUN (Co-PI Montalto) has been engaging in a multi-year effort in Darby-Cobbs watershed of southeast Pennsylvania with local academic, governmental, and nongovernmental partners to better understand the climate adaptation capacity of the watershed. To do this, the team has been working to characterize current and future flood exposure by developing models that simulate and visualize watershed-scale dynamic streamflow, surface flooding, and building spatial distribution. We have also worked with watershed stakeholders to co-develop a system dynamics model that represents the acute and chronic stressors faced by communities in the Darby-Cobbs watershed to enhance capacity and develop a preliminary adaptation plan. This capacity-building experience has also included the establishment of a Watershed Partners Team, made up of stakeholders from all parts of the watershed, as well as a Watershed Adaptation Corps, made up of community members from the watershed who are trained and paid to conduct community interviews and surveys, and gather physical, socioeconomic, and ecological data to inform the development of the system dynamics tool.

Ensemble Coastal Water Level Forecast System Survey

In our NOAA ORR (Response and Restoration) funded project, CCRUN (Co-PI Orton) surveyed 1600 users of our ensemble coastal water level forecast system (SFAS) with goals of learning their demographics, current uses of the forecasts, and future needs. Those invited are advanced users who are signed up to receive flood watch and advisory emails and may not reflect all the website's users, nor those who use information secondhand after it is shared by other users, which is common.

The 350 respondents were primarily (92%) non-Hispanic white, college educated (87%), middle- or high-income (although 28% preferred not to say), over 50 years old (81%), and a majority (67%) were male, setting a baseline for current users and helping motivate further outreach to diversify the user base. Of these, 99 respondents who share the information with their community or use it for government operations are aware of the forecasts affecting on-the-order-of 100,000 people (at least 64,890 people, and as many as several hundred thousand).

Common requests for improvement include graphical interactiveness, an SFAS app, text message notifications, altered email alerts (e.g. having user-selected alert thresholds), a guide or training slide deck, flood mapping, and an easier sign-up system for email alerts (on each station's page) and more SFAS stations. A summary of responses from those surveyed to activities taken in response to the SFAS is included later in this report.

Extreme Humidity and Heat

CCRUN's Climate Team (Lead-PI Horton) continued their research on the topic of extreme humidity and heat. In the current climate, higher temperatures and humidity impact the urban population centers of the Northeast, in particular vulnerable populations. With projections for more extreme heat and humidity in the future, cutting edge science to inform adaptation strategies is critical.

One paper published by CCRUN this project year derived a new variable which quantifies the individual contributions of temperature and humidity to a given value of extreme humid heat (Ivanovich et al., 2024a). The new ability to quantitatively characterize the drivers of extreme humid heat coming from modulations of temperature and moisture are also highly relevant to the Northeast so that we can more readily evaluate the variability of how heat stress events are caused in this region.

An additional paper investigated the effect of subseasonal precipitation variability on extreme humid heat during monsoons (Ivanovich et al., 2024b). Although not directly focused on the Northeast, this research does have relevance to the region, as the understanding of the interactions of extreme humid heat and precipitation can be applied to other locations. The Northeast has already experienced extreme precipitation events whose impacts could compound with heat stress conditions.

New York City Climate Change Vulnerability, Impacts, and Adaptation Study (VIA)

CCRUN's greatest accomplishment over the reporting period is the release of the New York City Climate Change Vulnerability, Impacts, and Adaptation Study (VIA), as described in the first section of this report. Presented here are more detailed descriptions of the key findings of each task the CCRUN team members participated in.

Task 2 - Climate Projections and Climate-Sensitive Hazards for New York City Region

Lead PI-Horton prepared updated sea level rise projections for New York City based on those developed for the IPCC 6th Assessment report. These projections are based on the CMIP6 models and SSP framework, and incorporate advances in process understanding, improved and lengthened observational records, and improved ice-sheet modeling. For sea level rise, the VIA projections show a high estimate of between approximately four to five feet of sea level rise by the end of the century in New York City. Projections are now available for the first time for all decades from the 2030s through the 2090s, 2100, and now, 2150. Interpreting the new results and comparing them to the projections from the 2014 New York State Climate Update (Horton et al., 2014) and New York City Panel on Climate 2015 (Horton

et al., 2015), these updated VIA projections for sea level rise are lower at the high-end 90th percentile, but broadly consistent at the 50th percentile. Despite these differences, these changes fall within the uncertainty we would expect with such projections, given the deep uncertainty about the amount of long-term sea level rise.

Co-PI Orton's research quantified the joint probabilities of storm surge and rainfall and studied the influence of storm type on compound flooding. Climate change is increasing the frequency of extreme precipitation events and elevating sea levels, increasing the likelihood of compounding either one of these flood drivers by the other. In addition, tropical and post-tropical cyclones (TCs) have caused severe storm surges and extreme rainfall to occur simultaneously. While assessment is limited by the small number of historical TC events, the limited evidence suggests that TCs can cause low-probability, dangerous compound flooding. Given the importance of TCs and limited historical data, a deeper understanding of compound flood hazards likely requires detailed modeling and downscaling to simulate such storms under the present and future climate (Rosenzweig et al. 2024; Chen et al. submitted).

Task 3 - Current and Future Extreme Heavy Rainfall in New York City
Co-PI Montalto co-led Task 3 of the VIA project. This task involved a literature review on extreme precipitation in the northeast and developing a Sustainable Stormwater committee consisting of local public, private, and community stakeholders who could help describe stormwater-related flooding challenges in New York City (NYC). The team conducted a long-term analysis into precipitation trends in the NYC area and also evaluated the extent to which historical precipitation events show evidence of Clausius Clapeyron scaling. In addition, they developed a methodology for generating new IDF Curves for the city, which were then generated. Finally, researchers explored the flooding implications of future precipitation using two NYC hydrologic and hydraulic models.

Understanding the characteristics and trends of extreme rainfall is critical for managing urban pluvial flooding, triggered by intense, localized downpours that overwhelm drainage network systems. Future projections based on updated climate models (CMIP6) indicate greater changes in daily extreme rainfall compared to earlier models. These changes include higher projected rainfall amounts for the 100-year storm event. There is only limited evidence to suggest the rate of increase for hourly precipitation extremes is faster than that for daily totals. Limited subdaily rainfall data hinders efforts to fully characterize pluvial flood risks, highlighting the need for a network of high-resolution rain gauges across the City and its watersheds. Analysis of historical trends reveals significant increases in the frequency and duration of events with extreme peak and average precipitation intensities, suggesting a future with more frequent and potentially more impactful pluvial floods.

Task 5 - Flood Vulnerability Index for New York City

Co-PI Madajewicz collaborated with Dr. Timon McPhearson and Pablo Herreros Cantis from the New School to develop a Flood Vulnerability Index for the City of New York. The City requested the index in order to identify the most vulnerable populations and to guide the City's efforts to reduce vulnerability to flooding in an equitable manner across the City's neighborhoods. The index was co-developed in close collaboration with representatives from City agencies who constitute the Inter-Agency Climate Adaptation Task Force (ICAT), who helped ensure that the index was well suited to address the decision problems to which the agencies intended to apply it. The index is now available as part of the Mayor's Office for Climate and Environmental Justice (MOCEJ) interactive Environmental Justice Mapping Tool, which allows the viewer to select different hazard scenarios included in the index.

The index has added to the **assets** available to the City of New York to advance resilience to flooding with attention to equity. The team advanced **learning** by discussing new research, on which we based the development of the index, with ICAT members. Exploring the reasons for the approach to the index, which is different from existing approaches in the literature, improved the understanding of the factors that influence vulnerability to flooding as well as of the information contained in an index and the ways in which that information can guide programmatic decisions.The indicators are informative in particular because they are specific to vulnerability to flooding, based on prior research, unlike the more generic sets of indicators typically featured in prior literature. The discussion improved the **capacity** of the partners to apply the index to decisions.

The development of the Flood Vulnerability Index (FVI) resulted in several contributions to research on vulnerability indices (Cutter et al., 2009)[1]. Several innovations have resulted in an index, which better reflects vulnerability to flooding specifically compared to prior approaches, provides clearer guidance for program and policy design, and maintains consistency in the rankings across locations as indicators of vulnerability change over time.

The *first contribution* is that the FVI includes exposure in a way, which both clarifies how exposure contributes to vulnerability in a graphical representation of the index and can be easily updated as new flood projections become available. The FVI consists of two sub-indices, one of which is based on the percentage of residential units within proximity to flooding under different flood hazard scenarios, resulting in different versions of the index for different scenarios. The other sub index consists of indicators, which are correlated with susceptibility to harm and capacity to recover. The *second contribution* is that the indicators of susceptibility to harm and capacity to recover are based on recent research that validates which indicators are correlated with outcomes experienced by coastal residents after flooding. The research on which the FVI is based includes CCRUN-supported research reported in Madajewicz 2020[2]. The *third contribution* is the approach to calculating the index using a geometric average, which has several advantages over other approaches in the literature.

Street Flood Sensing

In our street flood sensing project funded by MARACOOS since 2023, CCRUN (Co-PI Orton) has deployed ultrasonic sensors, cameras and accelerometer sensors in sewers to monitor flooding, and will be comparing the approaches and their pros and cons. An additional component of this effort is cross-collaboration with an ultrasonic sensor network (Floodnet.nyc), a camera network (WebCOOS) and the pressure sensor network (the Sunny Day Flooding Project), seeking to create a broader community of practice. The team has also been broadening collaborations to connect the research and deploy sensors alongside CCRUN Co-PI Montalto's ultrasonic flood sensors in Camden, NJ. The team has also obtained more funding from FEMA as a Cooperating Technical Partner, providing additional funding for ultrasonic flood sensors, connecting CCRUN Senior Personnel Marouane Temimi to the project (FEMA project PI).

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[1] Cutter, S. L., Emrich, C., Haney (Webb), J., & Morath, D. 2009. Social Vulnerability to Climate Variability Hazards: A Review of the Literature. *Final Report to Oxfam America*, 1–44.

[2] Madajewicz, M. 2020. Who is vulnerable and who is resilient to coastal flooding? Lessons from Hurricane Sandy in New York City. *Climatic Change*, 163(4), 2029–2053

Tradeoffs, Challenges, and Misaligned Incentives in Scaling Climate-Resilient Housing Across the U.S.

During the reporting period, a CCRUN researcher (Post-Doctoral Research Scientist Seeteram) finished data collection on a multi-sectoral expert elicitation aimed at understanding tensions across housing policy, finance, and development that prevent scalable solutions for climate resilient housing. The team anticipates a manuscript submission in August 2024.

For this work, 64 experts were interviewed to address the following research questions: (1) what risk-reduction strategies/policies are currently being implemented or proposed for new residential construction to reduce climate impacts on housing, (2) what barriers exist for implementation of these risk-reduction strategies/policies, and (3) what enabling conditions facilitate the adoption of these climate risk-reduction strategies/policies?

The recruitment methods to search for experts across six sector were organized by the categories listed and defined below: (1) ***government institutions***: federal, state, and local government officials working on climate resilience, disaster recovery, zoning, housing, or economic development issues; (2) ***housing finance and regulators***: climate risk and resilience officials at insurance and re-insurance companies, state insurance offices, and public-sector housing finance agencies; (3) ***real estate development and home-building***: officials at home-building companies, real estate development (affordable and market-rate) and investment firms; (4) ***academia***: leading academics and researchers at think tanks on issues of housing and climate risk and adaptation; (5) ***design***: urban planning, engineering, and architecture firms; and finally (6) ***advocacy***: officials at housing-focused non-profit organizations (national and community-based). One additional category (the seventh) was added; (7) ***information services*** to account for providers of climate risk information, or climate services.

In total, the researcher interviewed 64 professionals with the following professional breakdown: Academia (10%), Advocacy (18.8%), Design (17.2%), Government (23.4%), Finance and Regulators (12.5%), Information Services (3%), and Real Estate and Home Construction (14.4%). Most professionals identified as being mid- (45.3%) or late career (26.5%) and having spent 1-5 years in their current position (67.7%).

Through the preliminary analysis, the team identified five tensions and challenges that currently impede scalable solutions for resilient housing: (1) affordability and resilience tradeoffs, (2) misalignment between insurance and property-level risk-reduction solutions, (3) climate risk uncertainty and decision-making, (4) housing finance and equity considerations, and (5) future building code efficacy. The preliminary analysis suggests to the extent that any scalable climate resilience actions are occurring, and they are occurring within affordable housing development because of resilience mandates associated with their funding. This finding aligns with the 72.1% of responding participants (n=61) who indicated they believed legal mandates or laws are necessary to compel actors within their sectors to incorporate climate risks.

The findings from this research are particularly relevant to urban centers within the Northeast, where housing is both undersupplied and unaffordable, and where a diverse range of climate hazards pose threats. Where possible, decision-makers in these areas can use these conclusions to inform their long-term climate resilience and housing strategy.

Water Utility Climate Alliance (WUCA) Leveraging Data for Equitable Climate Outcomes

CCRUN (Co-PI Montalto) collaborated on the recently released Water Utility Climate Alliance (WUCA) Leveraging Data for Equitable Climate Outcomes case study, which outlines collaborative compound flood monitoring between the Philadelphia Water Department and academic partners including Drexel University in the Darby-Cobbs Watershed. Community-informed data is an essential tool to promote accountability, social resilience, and equitable climate action in the water sector; this research highlights the need for watershed-scale solutions that rely on multi-jurisdictional coordination in order to solve complex climate and flood issues.

2023 Managed Retreat Conference
Co-PI Madajewicz presents her research at the 2023 Managed Retreat Conference held at Columbia University, New York, NY.

OUTREACH AND ENGAGEMENT ACTIVITIES

2023 Managed Retreat Conference

In June 2023, Columbia hosted for the 3rd time a global conference on Managed Retreat. CCRUN was a primary partner, and NOAA staff again participated. Over the course of the event, there were numerous panels, some featuring speakers from other parts of the federal government including FEMA and CEQ. The conference spanned 3.5 days and featured close to 500 in person attendees and over 100 remote attendees. This conference is highly CAP-relevant, given that Managed Retreat and Migration have been identified as cross-program priorities.

Key themes of the conference included:

- Deep engagement by the public, private and nonprofit sectors, together with academics, scientists, and community representatives
- A major emphasis on issues of environmental justice
- Advancing the research agenda around managed retreat in an Interdisciplinary, solutions-oriented way.
- Facilitating networking and discussion among many types of stakeholders, and bridge the information gap between academics, practitioners, and affected communities; and
- Developing concrete solutions and best practices around a complex climate adaptation issue.

C-Heat Project Outreach

The C-Heat project engaged community organizations and residents in Chelsea and East Boston. These are frontline communities with every census tract meeting the Massachusetts definition of environmental justice. As a community engaged research project, there have

been many opportunities to interact, including the GreenRoots meetings, local interviews and regular meetings with staff from the City of Chelsea and City of Boston. Shared research findings across diverse platforms include academic conferences (CAFÉ Climate and Health Conference, International Society for Exposure Science), local conferences (Chelsea Research Festival, an event held at Chelsea High School to connect researchers and residents). Abstracts have been submitted and accepted for this year's International Society for Exposure Science and International Society of Environmental Epidemiology conferences.

Engaging with Communities around Jamaica Bay, New York City

Co-PI Madajewicz has engaged with frontline and underserved communities around Jamaica Bay in New York City to document vulnerability to chronic tidal flooding and pluvial flooding, both of which are much less well understood than storm-driven coastal flooding. The engagement includes focus group discussions organized with community groups and an ongoing household survey during which students are going door-to-door with a survey instrument in places that have been affected by tidal and pluvial flooding. Individuals who participate in discussions and in the survey are being compensated. The communities include Rosedale, an underserved, primarily African American middle-class community, which receives little investment from New York City and rare attention from researchers, and Edgemere, Arverne, and Somerville (on the Rockaway peninsula), primarily African American and Hispanic, low-income communities, also relatively neglected by the City, as well as several other more mixed and middle income neighborhoods.

Outreach to the Shinnecock Nation, Long Island, NY

Co-PI Madajewicz has been leading a co-production process with the Shinnecock Nation on Long Island designed to co-develop a flood adaptation plan for the community, and a decision framework for flood adaptation more broadly. Members of the tribe are participating in the research project, including the tribe's Director of the Environmental Department who is a co-PI. Tribal members who participate in planned workshops (4 are scheduled in the next reporting period) will be compensated. Already to date, the research team has met with the broader Shinnecock community.

Post-Extreme Event Learning Toolkit (PELT) Workshop

On February 29th, 2024, the CCRUN Team (Co-PI Solecki) ran a Post-Extreme Event Learning Toolkit (PELT) workshop in partnership with two Mid-Hudson Valley towns in New York State in response to an extreme rainfall event which occurred on July 9th, 2023. The workshop was applied with key flood policy stakeholders from the Town of Cornwall, Village of Cornwall-on-Hudson, Orange County, and New York State Assembly. PELT is a co-production process designed to take advantage of "windows of opportunity" following an extreme event. In the months leading up to the workshop the team met with local stakeholders and visited the sites impacted by the storm to better understand the context and craft questions to fit local needs.

The workshop's objective was to use PELT to help the local key policy stakeholders understand more completely what happened during the flood event and what might be relevant and valuable next steps to take in the long-term recovery process and improved flood resilience practice. Notably, the format fosters learning amongst participants, as well as from the facilitators, as they hear about others' experiences of the extreme event which may differ from their own. PELT provides communities vital time and space to define new policy pathways to address future extreme events and climate change more generally. The process seeks to transform short-term, post-event momentum into long-term learning and action. The application of the PELT resulted in a set of locally relevant recommendations and conclusions on climate challenges facing Cornwall, NY and possible adaptation practices to move forward.

Seminar Series

CCRUN's longstanding Green Infrastructure, Climate, and Cities and seminar series continued over the past year. A broad array of topics has been covered through the series, where for each event, invited speakers present on general themes related to climate science, climate impacts, adaptation and resilience, and mitigation. The series has hosted subject matter experts, allowed for cross-RISA collaboration, and engaged a number of local partners and community groups.

Over the reporting period, 8 seminars were held, topping approximately 525 attendees (an average of 65 attendees per session). More information about the seminar series can be found on the CCRUN website, including links to our Youtube page which archives the videos of past seminars.

Small Grants Program Outreach

Through the CCR small grants program, CCRUN has developed new and fostered existing co-production partnerships with four community-based organizations (CBOs) in frontline communities. In addition to the small grant related project work, which is led by the CBOs but supported by CCRUN researchers, CCRUN hosted a webinar (May 1, 2024) where CCR grantee organizations shared stories of building resilience in their neighborhoods. The webinar represented an opportunity to highlight the work of the CBOs related to their participation in the CCR program, but also to learn from peer organizations addressing similar challenges across the region. Other CBOs in the region, including those who applied to the CCR program, were invited to attend the webinar. Additionally, one CCR partner organization joined a CAP/RISA organized panel at the National Adaptation Forum in St. Paul, Minnesota in May 2024 to share their experience in the small grant program and the potential of these types of programs to advance more equitable funding options for community leaders, in conversation with representatives from other CBOs, research institutions, and government representatives.

CHALLENGES

Building New Partnerships

CCRUN (Co-PI Madajewicz) experienced several delays mainly due to the nature of building new partnerships. The process is slow and there is a learning curve in understanding how to best interact with each community. In the case of the partnership with Mastic Beach, the MOU required by the Town of Brookhaven, of which Mastic Beach is a part, took some time to complete. The team learned that the Town of Brookhaven is the governing authority because the local Mastic Beach village government recently dissolved. The team is still learning how to bring different parts of the community to the table in the Shinnecock Nation. Researchers are redesigning a household survey as a way to engage those who are not represented at the community meetings and workshops.

PLANNED ACTIVITIES

Land Use and Legacy of Resilience

CCRUN (Co-PI Solecki) is planning to work with the Canarsie Community Development Inc. (CCDI) to analyze how the concept of resilience is being redefined by residents in the decade since Hurricane Sandy. Canarsie is an environmental justice community in Brooklyn, located on the northern shore of Jamaica Bay in New York City. This neighborhood often has not benefited from the city's resilience initiatives following hurricane Sandy. Therefore, the CCDI is redefining resilience to link flood risk reduction with increasing overall well-being for community members. Following multiple discussions, the project will focus on how past local land use including land filling, current practice including paving over remnant green space for parking and other uses, and future land uses including community gardening and increased use of pervious surface materials are linked together in an effort to promote increased quality of life in the community and the mitigation of street level flooding.

Continuing Small-Grants Program

The Equity Team (Co-PI Leichenko) is planning to continue engagement with several CCR grantee organizations in the coming year to explore how CBOs in the region conceptualize and operationalize equity their adaptation related work to both meet the needs of their communities and to secure funding from institutional partners. Results from these activities aim to enhance **learning outcomes** relating to varied understandings and applications of equity

within adaptation planning and improve **flexibility** of ongoing institutional efforts to fund projects relating to climate justice and adaptation. The team plans to co-develop workshops to explore equity in adaptation with partner CBOs to meet the needs of their communities and organizations, building on their organization's **sense of agency** for leading adaptation efforts in their areas. By developing a better understanding of community and organizational priorities for equitable adaptation in the region, the workshops will also contribute to the Equity Team's efforts to co-produce understandings of vulnerability and resiliency with community members in the region, and to assess impacts of existing adaptation efforts in frontline communities.

PROGRAM IMPACTS EVALUATION

The CCRUN program evaluation is assessing progress toward the program goal of improving adaptation to climate risks in the urban Northeast. The three components of the evaluation are the program theory, monitoring, and evaluation.

Program Theory

The program theory describes what actions and inputs can bring about the improvement in adaptation that CCRUN intends to achieve, through what causal mechanisms, and what are outputs, outcomes, and impacts that the team should be measuring. The program theory has four broad components that articulate how CCRUN may achieve interim objectives on the path to achieving the goal of improved adaptation: (1) co-producing science that is useful for decision-making, (2) supporting the processes of putting that science to use, (3) co-designing and co-implementing uses of science that advance adaptation, (4) learning through evaluation to improve the work in each of the other three components. We aim to make the learning process, which has been occurring since the beginning of CCRUN, more systematic during this 5-year phase.

The approach to program theory in CCRUN is to develop specific program theories for different decision problems and contexts that can support the design of evaluations of specific engagements. Co-production spans a very broad range of types and intensities of engagement with different types of stakeholders. The specific inputs, actions, participants, and causal mechanisms that compose effective engagement are likely to differ across decision problems and contexts. The long-term goal is to co-develop with stakeholders a program theory for decision support that articulates how the process differs across decision problems, types of stakeholders, and environmental, socioeconomic, and governance conditions.

Monitoring

The monitoring system has been tracking a consistent set of process indicators since the early years of CCRUN. This report features numerous examples of stakeholder engagements and the results based on the monitoring process. The indicators inform the team whether the CCRUN process is advancing toward the objectives of useful science and support for decisions based on that science. The process indicators fall into the following categories.

- The decision makers with whom CCRUN researchers are working, including the length of the relationship and decision problems addressed. Activities undertaken with decision makers, for example design and implementation of approaches to adaptation.
- Climate information/decision support tools co-developed with the decision-makers
- Publications in outlets read by decision-makers.
- Decision maker testimonials
- Outreach to communicate research results and use cases to decision makers.
- Engagement with scientists
- Presentations of results in various research venues
- Peer-reviewed publications/citations of peer-reviewed publications
- Broad communications
- Contacts with the media
- Number of views of various parts of the CCRUN website
- Number of social media posts

As part of the monitoring process, CCRUN is collecting data on outcomes of engagement, such as how information was used or what new planning and/or policy processes resulted, and impacts, such as reduced damages from flooding, in the context of specific engagements. For example, we have been documenting awareness, climate impacts, recovery, and adaptation actions specifically in the context of flooding in New York City (NYC) to establish baseline data that will allow the team to document how adaptation, vulnerability, and resilience are evolving over time given the use of flood projections to improve adaptation since Hurricane Sandy. The team has baseline data on vulnerability and resilience to storm-driven coastal flooding among urban residents in two areas of NYC, Rockaway and South Shore of Staten Island, collected after Hurricane Sandy. We are currently adding to baseline data, through two projects, one funded by the City of NY, Vulnerability, Impacts, and Adaptation (VIA) and one funded by USGS, by collecting data on vulnerability and adaptation to pluvial and tidal flooding in six different neighborhoods of NYC. The data will enable the team to assess changes in resilience and adaptation over time by collecting similar data after future coastal storms and tidal and pluvial flood events.

Another type of baseline data that the team has collected document current decision processes and needs among decision makers in municipalities in New Jersey and on Long Island. The data will enable the team to assess how the adaptation process evolves over time in response to future engagements in those municipalities.

The team has collected baseline data through a small pilot survey on shocks experienced, and adaptation actions taken by 50 small and medium business owners and operators in coastal areas of NYC and four northern NJ towns. We aim to expand the data set in the future. The data will enable the team to track changes in qualitative severity of shocks and in adaptation behavior among small and medium businesses over time as new climate events occur and new adaptation initiatives are implemented, comparing the evolution of adaptation in the large urban metropolis of NYC and in smaller municipalities.

The team also has been continuing its work with local New Jersey and Long Island shore practitioners and policymakers regarding their information and data needs on how households are utilizing the resilience planning programs developed for their use.

Evaluation

CCRUN current and future evaluation efforts rely on a number of approaches, depending on the particular evaluation problem, including ex-ante evaluation and the following approaches to ex-post evaluation: theory-based evaluation, contribution analysis, non- and quasi-experimental econometric methods, and field experiments when appropriate. Ex ante evaluation assesses the potential outcomes and impacts that may result from the use of climate information or an investment in adaptation in the future, based mainly on models. Ex post evaluation assesses outcomes and impacts that occurred as a result of a particular engagement with information and/or investment in adaptation, based on data. The outcome and impact indicators are specific to decision problems and contexts. Outcome indicators may include changes in awareness of climate risks and adaptation options, attitudes toward climate impacts and adaptation actions, adaptation planning, policies, codes, standards, regulations, management decisions, capital investments, allocation of administrative resources, and individual and collective adaptation actions by urban residents. Impact indicators may include losses due to extreme events, economic outcomes such as value of infrastructure, small business activity, employment, incomes, safe housing, and other quantitative and qualitative measures of livelihoods, such as health, neighborhood quality, etc. Important outcome and impact indicators are ones that measure the distribution of various outcomes and impacts in the population to capture the equity of progress on adaptation, for example gentrification of neighborhoods, adaptation in historically disadvantaged communities, access to housing, performance of small businesses, changes in employment patterns, etc.

A current project is evaluating the outcomes of co-producing information about local flood risks and costs and benefits of adaptation options on adaptation behavior among coastal residents in NYC. It is comparing adaptation behavior that results from engaging community group members in co-producing the information and discussing it through in-person workshops with behavior that results when information is available through outreach designed without co-production and online. It also investigates whether the effectiveness of the co-production approach differs for populations with different socio-economic characteristics. The evaluation is using a mixed method approach, integrating qualitative information from workshop and meeting transcripts with a quantitative, quasi-experimental approach known in econometrics as a difference-in-difference analysis, based on baseline and follow-up survey results. The econometric approach is widely used to evaluate social programs but has rarely been applied to understand the impacts of climate-related initiatives. Perhaps the least expected result is that improved understanding of risks and adaptation options at the level of the individual household motivated participants to start exploring options for collective, community-level planning.

Our team has begun a new project, which is combining ex ante and ex post methodologies to assess the effectiveness of approaches to flood adaptation based on participatory modeling of tradeoffs between adaptation strategies and participatory selection of adaptation strategies.

In another planned approach, data collected through monitoring will help to identify case studies in which the team will investigate how science that CCRUN has co-produced with policymakers is being used by practitioners in the urban northeast region and beyond, what outcomes are emerging from that use, and what are the likely impacts. Case studies will be designed based on detailed program theories.

An evaluation challenge is that outcomes and impacts can be observed only in specific contexts. The team is continuing to investigate how to select evaluation cases strategically and what methods to apply in order to provide evidence that can be aggregated to measure broader program impacts. An ongoing project is specifically designed to compare the effectiveness of a decision support framework for flood adaptation planning across four study sites, which have strategically selected differences in environmental, socioeconomic, and governance conditions. The results will inform applications of the framework to flood adaptation planning in other locations depending on how conditions in other locations compare to conditions encountered at the study sites. Another continuing challenge is the availability of appropriate data for evaluation and resources to collect appropriate data.

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EVIDENCE OF SOCIETAL IMPACT

C-HEAT

The goal of the C-HEAT project is to build resilience to extreme heat in the frontline communities of Chelsea and East Boston, Massachusetts. Funded by Barr Foundation and NOAA, it brings together researchers, community members, and city staff to understand the challenges of extreme heat where we work, play and live. Greenroots, one of the partners on this project, was the recipient of a CCRUN Community Grant to engage residents around park design and community needs related to extreme heat and the C-HEAT team supported the related community events.

In the last year, the team focused on maintaining the fine-scale geospatial database of temperature and population vulnerability data, cooling resources, and built environment infrastructure, used by researchers, community organizations and city staff to make decisions around cooling interventions in the city. **Assets** such as this database help ensure climate-informed decision making is incorporated into resiliency planning.

Key research findings have been shared across diverse platforms, including academic conferences (CAFÉ Climate and Health Conference, International Society for Exposure Science), local conferences (Chelsea Research Festival). Abstracts have been submitted and accepted for this year's International Society for Exposure Science and International Society of Environmental Epidemiology conferences. In addition, continued boosting raised awareness of extreme heat and solutions through published academic articles, presentations, Twitter and LinkedIn posts. The public display of this information can improve citizens **learning** about climate impacts and adaptation.

Ensemble Coastal Water Level Forecast System

As described earlier in the report, CCRUN (Co-PI Orton) surveyed users of our ensemble coastal water level forecast system (SFAS) with goals of learning their demographics, current uses of the forecasts, and future needs. In addition to the results previously summarized, the survey also tabulated many important emergency management actions taken by governments to prevent flooding, based on our forecasts. Common response activities include closing flood gates or storm surge barriers, moving cars to higher elevation, closing roads, protecting industrial equipment, preparing facilities to accommodate floodwaters, situational awareness, moving items in ground-level garages and spaces off the floor, triggering emergency management activities, and issuing public relations notices to the public.

Going beyond the survey results, CCRUN (Co-PI Orton) obtained evidence of the impact of our SFAS water level forecasting from several stakeholders, including the following quotes from emails and letters of support:

> **"[Stevens forecasts] have been tremendously helpful during our forecast and warning operations. Not only has this guidance helped forecasters make routine day-to-day tidal forecasts, but it also increased their confidence during [storms]."** - Robert Deal, National Weather Service, Mt. Holly (NJ/PA)

> **"If public safety is the foundation of municipal services, then Stevens forecasts are the foundation of datapoints that we rely on to prepare for, respond to, and recovery from coastal hazards."**
> - Caleb Stratton, Chief Resilience Officer, Hoboken.

> **"[Stevens forecasts] are an indispensable source of data used by NYCEM's meteorologist and emergency planners ... leading up to and during storms."** - Joshua Rapp, New York City Emergency Management

New York State Climate Impacts Assessment

For many years, CCRUN climate science researchers have worked on the State of New York's climate assessment planning process. Working with the New York State Energy Research and Development Authority (NYSERDA), CCRUN (Lead-PI Horton) prepared climate change projections for the first statewide assessment in 2011, and then in an update in 2014. Most recently, work on updating projections began in late 2020, with CCRUN again leading the effort on the climate science components, culminating with the release of the NYSCIA in late 2023. (Bader and Horton, 2023; Lamie et al., 2024) The new data is another **asset** in the growing "catalog" of information available to stakeholders in New York State.

These latest projections in NYSCIA (in addition to those prior) are informing policy at the state and local level. Specifically, with this update of the climate science information, New York State is requiring electric utilities to prepare climate change vulnerability studies and updating regulations to incorporate the latest sea level rise data.

Public Service Commission

The New York State Public Service Commission required major electric utilities to perform climate vulnerability studies to help prepare for the expected increase in severe weather expected from climate change. The major utilities completed these reports in late 2023 and they are currently being reviewed, with the expectation that the PSC will approve or modify the plans by later 2024. The climate science that is used in the individual utility vulnerability studies comes from CCRUN's data from the NYSCIA.

Each plan is required to consider the impacts of climate change to utility infrastructure, how to reduce restoration costs and outage times associated with extreme weather events and enhance system reliability. From maintaining the capacity to power the grid during heat waves (and thus keep air conditioners running) to preventing floodwaters from entering generating stations, CCRUN's science, combined with subject matter expert knowledge at the utility, is helping to keep the power on for residents of New York State.

In addition to providing the climate science of record for the utilities, CCRUN participated in a series of stakeholder conversations with utility representatives in which scientists presented the data, received critical feedback, and co-generated additional projections when needed, reflective of the diverse baseline climate, and energy needs and mix across the State. For example, additional metrics for extreme temperature (hot and cold) were added beyond what was included in NYSCIA for utilities in the northern part of the state, as their climate is quite different than the New York City metropolitan region. Already a knowledgeable group of practitioners, these discussions advanced **learning** and further advanced the **sense of agency** at the utilities to prepare for future weather and climate risk.

Sea Level Rise Regulations

New York State's CRRA of 2014 requires the New York State Department of Environmental Conservation (DEC) to adopt science-based sea-level rise projections into regulation by January 1, 2016. In 2017, DEC adopted 6 NYCRR Part 490, Projected Sea-level Rise, which codified the projections developed by the CCRUN team. With the 2023 update of sea level projections (led by CCRUN), DEC proposed an amendment to 6 NYCRR Part 490 to incorporate the latest science into the regulations. The public comment period for the amendment ended in April 2024, and the proposed legislation would update the projections with data the team prepared for the New York State Climate Impacts Assessment.

To date, the projections have been incorporated into conditions of both site-specific and general permits that cover numerous projects in the state's coastal areas. They are also being used to inform community vulnerability assessments and planning, and updates to the state building codes.

A community event at "Blooming Park," a formerly vacant lot transformed into a "Cool Block" demonstration area with temporary heat mitigation solutions, including cooling and hydration stations. Photo by GreenRoots.

CASE STUDIES

Greenroots

Greenroots is a community-based organization in Chelsea, MA, an underserved community just outside of Boston, MA. CCRUN began working with Greenroots in 2021 through the C-Heat project (described in the section above). This initial phase of work focused using satellite data to determine that this neighborhood was one of the hottest in the city and was a priority for intervention given the proximity to highly dense housing, the Boys & Girls club, a soccer field and playground, and an Islamic Center.

Greenroots saw a vacant lot, located at 212 Congress Ave, as an opportunity to begin a pilot program for strategies to mitigate the effects of the urban heat island. The "Cool Block" project, where GreenRoots engages community members in the neighborhood to collaborate with the City of Chelsea and other partners, was launched to implement cooling strategies around this location. The block level approach consists of significant tree planting along the site's perimeter and two major interventions at each bookend: the installation of a white roof at the Boys and Girls Club and at the other end, the transformation of 212 Congress Ave. into a lush, new, permanent green space with cooling and hydration stations.

To continue and expand upon this work, Greenroots applied for (and was later awarded) a CCrUN CCR small grant. In this phase, community outreach expanded and Greenroots held numerous community engagement and visioning events to gather feedback, understand needs, and collect ideas from the community. Community feedback and input has been essential to thinking about how this vacant lot could be transformed into a community space that also provides cooling effects for the whole neighborhood. Funding from the small grants program has also been used to purchase materials for projects and provide stipends to 15 families in the neighborhood so that they could participate in a summer-long tree watering. The vacant lot at 212 Congress Ave. is now known as "Blooming Park", a reflection of the transformation that is taking place with the support of CCRUN and the community.

Groundwork Elizabeth

Elizabeth N.J. is a densely populated culturally diverse environmental justice urban community that faces significant weather and climate risks from rising temperatures and increased heavy precipitation. Of the 39,000 households in the city, 78% are defined as non-white and many are low to moderate income residences with little access to natural open space. Impervious surfaces cover most of the city and facilitate flooding and related heat concerns.

The United States Environmental Protection Agency and United States Forest Service have designated the Elizabeth River and the adjoining Trotters Branch tributary sites as one of their Urban Waters Federal Partnership locations (Site ID 16, Passaic River/Newark, New Jersey). Flooding and contamination from runoff at these locations caused by a changing climate pose a threat to human and natural life along the local Elizabeth watershed which feeds through the poorest neighborhoods in Elizabeth into the regional Newark Bay watershed.

Groundwork Elizabeth's ultimate goals are to mitigate challenges to our urban community's environment while fostering environmental justice within diverse and underserved redlined City neighborhoods. To achieve this goal, the organization applied for and was then awarded a CCRUN CCR small-grant for the "Trotters Branch/Elizabeth River Restoration project". For this project at Trotters Branch, our overarching outcome is to protect the vital watershed so that it acts as an ecologically functioning waterway conserving the site for plants, animals and improving the space to help us make our most environmentally challenged neighborhoods healthier and safer for all who live here.

CCRUN worked with Groundwork staff to document the watershed and associated heat challenges for the community and created an easy-to-read story map and separate maps which were translated into Spanish via Rutgers translation services for the City's large Latinx population and a narrative of the dangers that Elizabeth was experiencing. Funding from CCRUN also helped engage our community, pointing out the dangers of the erosion, which will help lead to restoration of specific elements of the natural functions and health of the watershed.

Urban Heat Island Mitigation in Philadelphia

In CCRUN's (Co-PI Montalto) heat mitigation project aimed at addressing extreme heat and job loss due to the COVID-19 pandemic, researchers have been working in frontline, heat vulnerable communities throughout Philadelphia. Originally piloted in Hunting Park, North Philadelphia, in this report period, the team has expanded the installation of sprinklers and bench planters into four additional communities in Southwest Philadelphia: Kingsessing, Haddington, Grays Ferry, and Point Breeze.

CCRUN is partnering with community-based organizations from each community to hire and train construction ambassadors to fabricate and install shade stations featuring an umbrella, bench, and planter. These shade stations provide communities with green, shaded places to sit on blocks that do not offer significant tree canopy or covered porches to escape urban heat. This project presents an alternative to street trees while still providing green spaces and shade to communities. In addition to hiring community members to construct the shade stations, the team also hires and trains civic scientists from each of the partner communities to engage in monitoring work with various heat sensors to validate the effectiveness of the cooling strategies implemented in each neighborhood.

The research directly responded to residents in this area of the city, as they expressed concern regarding the need for shade in their neighborhoods as well as a lack of resources required to maintain young street trees.

Urban Heat Island Mitigation: Planter benches lining a block in the Kingsessing neighborhood of Philadelphia, offering shade, native greenery, a comfortable place to sit, and beautification for the community.

COMMUNITY CLIMATE RESILIENCE GRANT COMPETITION

The CCR small grant program, which launched in May 2022, formally concluded May 1, 2024. To mark the conclusion of the program, each organization joined a webinar to share the details of their projects and discuss challenges and opportunities for building equitable resiliency in their communities, hosted on the CCRUN YouTube channel. Additionally, as each funded organization completes their project, they are publishing a blog detailing their work on the CCRUN website. Two grantee organizations have completed and reported on their projects, and two grantee organizations are completing projects with a no-cost extension through June 30, 2024. CCRUN will continue to partner with all CCR organizations for a variety of research activities and projects, including co-developed workshops relating to equity in adaptation.

Initial analysis of the CCR program design has been summarized in a paper in Community *Science* (in press), and also presented at several conferences and meetings including Geography2050 in New York City in November 2023, at the CAP Network Meeting in Seattle in November 2023, and at a CAP/RISA organized panel at the National Adaptation Forum in St. Paul in May 2024.

APPENDIX A. CCRUN PUBLICATION LIST

Peer-Reviewed Publications

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Ivanovich, C. C., Horton, R. M., Sobel, A. H., & Singh, D. (2024). Subseasonal Variability of Humid Heat During the South Asian Summer Monsoon. *Geophysical Research Letters*, 51(6), e2023GL107382. https://doi.org/10.1029/2023GL107382

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