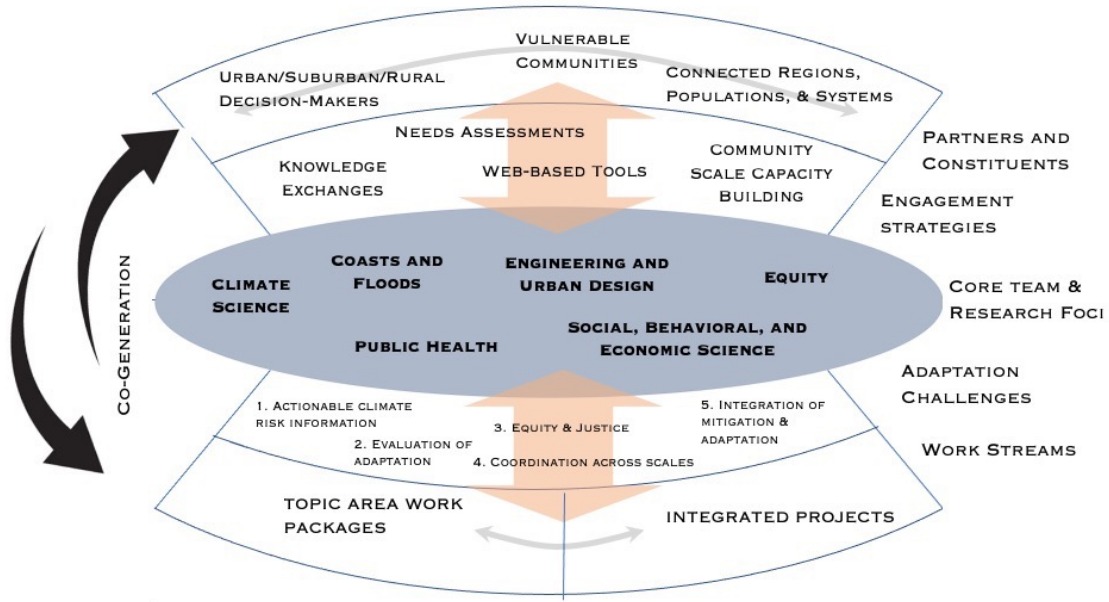# CCRUN

CONSORTIUM FOR CLIMATE RISK IN THE URBAN NORTHEAST

A NOAA CAP/RISA Team

Supporting Regional Implementation of Integrated Climate Resilience

NA21OAR4310313

Research Highlights,
June 1, 2022 – May 31, 2023

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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Program Manager - Daniel Bader (Columbia University)

Co-Investigators - Patrick Gurian (Drexel University), Jeanne Herb (Rutgers University), Nariman Mostafavi (Drexel University), Elizabeth Watson (Drexel University, now at Stony Brook University)

Senior Personnel - Marjorie Kaplan (Rutgers University), Patrick Kinney (Boston University) , Marouane Temimi (Stevens Institute of Technology)

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STAKEHOLDERS AND PARTNERS

Camden County Municipal Utilities Authority
City of Camden, New Jersey
Consolidated Edison
Eastwick United
Edgemere Alliance**
Empowered CDC**
Esperanza
Farmer JAWN**
FEMA Region 2
Global Thinking Initiatives Inc**
Greenroots
Groundwork Elizabeth**
Groundwork Hudson Valley**
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 Department of Parks and Recreation
New York City Mayor's Office of Climate and Environmental Justice
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
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
Shinnecock Indian Nation**
Town of Brookhaven, New York**
University City District

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

KEY ACCOMPLISHMENTS

With a principal focus on the urban northeast corridor from Philadelphia through New York City to Boston, CCRUN has engaged with numerous stakeholders across multiple-sized cities in the region. In recent years, CCRUN's work has shifted from working primarily with local governments and municipal agencies in the larger cities to working additionally with small-to-medium sized cities and local communities throughout the region. Our researchers, working together with stakeholders and residents, continue to partner together to deliver the best-available local science information that is utilized in building a resilient and sustainable future.

This past project year marks our deepest engagement within communities in the urban Northeast. Throughout this report, there are many examples of CCRUN's work at the neighborhood-scale, in many cases working with frontline and underserved communities. These include:

- Advancing the C-HEAT project, which is helping to build resilience to extreme heat in the frontline communities of Chelsea and East Boston, Massachusetts. This project brings together researchers, community members, and city staff to understand the challenges of extreme heat where residents work, play and live.

- Completing the 'Homeowners' guide to adaptation,' which transfers to communities the knowledge co-developed with leaders and members of community groups in the Rockaways, Queens, New York.

- Expanding CCRUN's capacity to mitigate the urban heat island effect throughout the Philadelphia area. The team has expanded the installation of sprinklers and bench planters into four additional communities in Southwest Philadelphia.

- Proposing new research that involves a significant amount of preliminary co-production processes in underserved communities in Brooklyn, New York and Queens, New York. These proposed efforts include a community partner and habitat restoration area within these two boroughs of New York City.

- Restarting a climate forum series with New York Sea Grant, moving to the northern part of Queens in the neighborhood of Flushing, New York. The theme of these forums was flooding from extreme rainfall. This part of New York City experienced significant impacts from the remnants of Hurricane Ida in September 2021.

In addition to these initiatives, during the reporting period CCRUN launched its inaugural small grant program, the Community Climate Resilience (CCR) Grant Competition, in the summer of 2022. Four programs have been funded with one-year grants, with projects set to conclude in January of 2024. The partners selected for the CCSR grant competition also were required to identify the potential environmental justice impact of their projects and detail the specific communities where they work.

Long considered first responders to climate change impacts, smaller cities and urban communities are finally increasingly having a chance to formulate research questions and share expertise to inform risk assessments and solutions, in part through small funding opportunities like the CCR.

NEW AREAS OF FOCUS AND PARTNERSHIPS AND KEY RESEARCH FINDINGS

Academic Network to Support Urban Water Resilience

CCRUN (Co-PI Montalto) partnered with local stakeholders in Philadelphia, PA including the Philadelphia Water Department (PWD) and the Office of Sustainability (OOS), as well as University of Pennsylvania and Villanova University to establish an Academic Network to Support Urban Water Resilience (ANSUWR). ANSUWR explores multifunctional strategies for making the city more resilient to climate change. The focus is on how climate change will alter conditions in the city's neighborhoods, specifically 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, University of Pennsylvania, and Villanova University) 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.

Advancing Community Resilience to Cumulative Climate Impacts in the Mystic River Watershed

The Advancing Community Resilience to Cumulative Climate Impacts in the Mystic River Watershed (ACRES) project is a new Research to Action grant the CCRUN Public Health Team (Co-PI Fabian) received from the United States Environmental Protection Agency in partnership with Mystic River Watershed Association (MyRWA) and other local community organizations. The goal is to better understand how 21 frontline communities in Greater Boston's Mystic River Watershed are affected by chemical and climate stressors, and how they can become more resilient to the current and future impacts of climate change. ACRES launched early 2023 and is partnering with CCRUN researchers to share data and modeling approaches to climate hazards.

Coastal Communities Partnerships

Co-PI Madajewicz has begun to develop new partnerships with the Town of Brookhaven on Long Island and the Shinnecock Indian Nation on Long Island, and through collaboration with the MARISA team, with one municipality and one tribal community in coastal VA. The partnerships have two objectives. First, we propose to co-develop with the communities a decision support framework that can help to select flood adaptation options, which can most effectively achieve the communities' objectives. The framework would be applicable beyond the study communities, along the Atlantic coast. We would investigate how the framework can be adapted to the different environmental, socioeconomic, and governance conditions represented across the study communities. Second, as part of creating the framework, the project would test approaches to building flood adaptation capacity in coastal communities, which we have developed in coastal neighborhoods of New York City, in other contexts and investigate if and how the approaches can be translated to and scaled up under different conditions.

Coastal Resilience Planning and Programming

With respect to effective coastal resilience planning and programming, CCRUN (Co-PI Solecki) examines how climate change risk is intersecting with everyday lived experience of at-risk coastal households and businesses. The key questions are how are households perceiving climate risk, how are they acting or responding to local resilience programs?

Submitted research documents the results of a study in Long Island and New Jersey that indicates not only a significant variation in risk perception, but also a widespread lack of knowledge and appreciation of many resilience efforts available to residents and a lack of trust of many sources of information about flood risk. Furthermore, many residents felt that their climate risk exposure and vulnerability will increase in the future and that government programs will have limited ability to reduce the risk. Despite this, most residents are reluctant to move away from the coast. Instead, they are taking actions to plan for the next extreme event with some investing in physical adaptation measures like elevating their homes or moving critical infrastructure to upper levels of the house.

Coastal Storm Risk Management Strategies

CCRUN (Co-PI Orton) played a prominent national role in the science-based assessment of coastal storm risk management (CSRM) strategies. Our research and expertise were requested to inform public comment on a regional CSRM study (New York/New Jersey Harbor and Tributaries) by the National Park Service, the National Parks Conservation Association (NPCA) and Rebuild by Design.

The team published two papers, gave three invited lectures, and this work resulted in a doctoral dissertation (Chen, 2022) and PhD degree (Orton et al. 2023; Chen and Orton, 2023), as well as a PhD degree and dissertation (Chen, 2022). Within this work, CCRUN also broadened the palette of nature-based options for coastal flood risk reduction and have set up a meeting with the USACE Engineering with Nature leadership to occur in mid-June.

Collaboration with the Northeast Climate Adaptation Science Center

In another new partnership, Co-PI Madajewicz and Co-PI Montalto have joined a funding proposal with the Northeast Climate Adaptation Science Center (NECASC), which is designed to develop research on the connections between climate, urban ecosystems, and society within NECASC. Social-ecological research in urban and residential landscapes is rapidly expanding. For NECASC to be effective in this arena, the partnership proposes to engage biophysical and social scientists, stakeholders, and practitioners in. developing a detailed plan that will help guide NECASC investment and serve as a blueprint for cooperative commitment across NECASC, FS-NRS, and CCRUN to do research and technology transfer on climate change implications in urban and residential natural resources. The overall goal is to promote 'win-win' solutions for both nature and people. While this social-ecological approach is essential in these highly developed and densely populated northeastern landscapes, the group believes that it could very well serve as a model for climate adaptation across the entire urban-to-rural continuum.

Collaboration with U.S. Geological Survey

CCRUN (Co-PI Orton) began a project and collaboration with researchers from the U.S. Geological Survey to develop and apply hydrodynamic modeling to study coastal-pluvial flooding. The main collaborator is John Warner, the lead developer of the Coupled Ocean Atmosphere Wave and Sediment Transport (COAWST) model. This 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 Institute of Technology and more broadly across the COAWST user base.

Evaluation of the Co-Production Process

Co-PI Madajewicz is in the process of completing the evaluation of the co-production process, which CCRUN undertook to build capacity to adapt to flooding in coastal communities in the Rockaways in New York City. The research addresses the challenge that coastal residents are not yet adapting to flooding on any substantial scale despite increasing risks and the importance of decisions by residents to adaptation outcomes. Motivating residents to adapt is an important priority for the municipal governments along the northeastern coast.

The purpose of the evaluation is to identify lessons that can be applied to building capacity in other coastal communities. The collaboration with communities resulted in the co-development of very different information than had been disseminated to communities through various outreach efforts undertaken since Hurricane Sandy. The outcomes that resulted from this new information include a substantial shift in residents' attitudes toward taking adaptation action.

Attitudes changed from disengagement, a perception that there were no actions that residents could take given their available resources, and that adaptation was the responsibility of government to a sense of agency and urgency, a perception that residents both can and must take action as soon as possible. The initiative improved residents' understanding of risk and quantitative benefits of adaptation, estimated as the reduction in future flood recovery costs that residents could achieve with a range of different adaptation actions, at the level of their individual homes and families. Unlike actions recommended by previous outreach efforts, they could find actions that were feasible for them in the broader menu. The evaluation also identified evidence that behavior was beginning to change even within the short term of the evaluation, which covered only one year after the intervention.

Homeowners' Guide to Adaptation

CCRUN (Co-PI Madajewicz) finished the 'Homeowners' guide to adaptation,' which transfers to communities the knowledge co-developed with leaders and members of community groups in the Rockaways. The guide is an online story map. It conveys the flood projections, estimates of flood recovery costs in the absence of adaptation, and benefits and costs of adaptation actions, which residents can take on their own with their own resources, co-developed by researchers and community group leaders in the course of the NOAA-funded "Enabling urban residents to adapt to coastal flooding: Evidence from New York City neighborhoods" project.

The guide discusses a process that residents can follow to use the information to make decisions about adaptation. It also contains information, which had an impact on knowledge, mindsets, sense of agency, perception that residents are responsible for adaptation action, and adaptation behavior during workshops with community groups. The team will continue dissemination and plans to hold a public event to discuss the guide and adaptation to flooding in the fall. While the guide is specific to the Rockaways, it is based on an approach to building capacity to flooding that is more generally applicable and can serve as a template for other communities with appropriate flood projections.

New York City Climate Vulnerability, Impact, and Adaptation Analysis

Several CCRUN researchers (Horton, Montalto, Madajewicz, Orton) started work on a new project funded through the New York City Town and Gown Funding Program. The primary task for the project team is to complete a Climate Vulnerability, Impacts, and Adaptation Analysis. (VIA) for New York City, with the primary stakeholder being the New York City Mayor's Office of Climate and Environmental Justice. This work will also. interact with ongoing efforts of the Fourth New York City Panel on Climate Change (NPCC), an advisory body to the Mayor's Office in which CCRUN team members played a foundational role and continue to participate. Specific contributions to this project by the CCRUN team include:

For Task 2 of the VIA Project "Climate Projections for New York City Region"
CCRUN's Climate Science team (Co-PI Horton) has worked on 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. The sea level rise projections were developed in coordination with the New York State Climate Impacts Assessment (NYSCIA) to ensure that the methodologies are consistent in New York City. The NPCC climate science working group also contributed to these projections and offered guidance on the selection of scenarios and presentation of results.

As another component of this Task of the VIA project, the CCRUN flooding team (Co-PI Orton) is providing "on-demand climate risk information and research" to New York City on coastal-pluvial compound flooding, a growing concern with flood risk.

Flood risk and adaptation assessments for low-lying areas with vulnerability to both heavy rainfall and storm surge should assess rain, surge, and compound flooding from the two. Also, areas susceptible to rare, extreme tropical cyclones, may experience unusually severe conditions that appear as 'outliers' in comparison to other much more frequent storms, particularly when it comes to compounding flood sources. While recent studies have provided evidence of widespread joint occurrence of extreme rainfall and storm surge, few studies have investigated their co-occurrence mechanisms in detail.

Here, the CCRUN team (Co-PI Orton) presents a probabilistic coastal-pluvial flood hazard assessment for New York City (NYC) and analysis of the role of hurricanes and their varying storm tracks. Our researchers use hourly storm surge data from the Battery and Kings Point tide gauges as well as observed rain data from stations within 25 km of NYC to perform a multivariate extreme value analysis. The team evaluates their dependency by using Kendall's rank correlation coefficient and copula models and compares the results for overall dependency and upper tail dependency. CCRUN scientists also use storm track data to separate and perform the analyses only on data from hurricanes, which are rare but may have different tail characteristics. Lastly, future work will evaluate historic trends in rain-surge correlations to assess whether climate variability or change may be affecting compound events for NYC.

For Task 3 of the VIA Project "Current and Future Extreme Heavy Rainfall in New York City"
Co-PI Montalto's team is working to create a summary literature review that includes the results of informant interviews. The team will develop an event ranking and historical trends analysis of observed rainfall events, as well as preliminary IDF curves and a report detailing background and methodology.

Further, the team will also develop a scope of work for additional climate analysis, and a report summarizing modifications to the preliminary IDF curves based on feedback from the Client Team, NPCC Flooding Work Group, and Stormwater Steering Committee established for the project.

For Task 5 of the VIA Project "Flooding Vulnerability Index for New York City"
This task focuses on developing a flood vulnerability index (FVI) for the City of New York. Co-PI Madajewicz is co-leading the team, which has completed a literature review and a draft index, which makes several contributions to the existing body of work on vulnerability indices. The results of the work so far will be included in the next New York City Panel on Climate Change (NPCC) report for the City of New York and will help to guide the siting of flood censors under the Flood Net project, which aims to improve flood monitoring in New York City. The development of the FVI has built an asset, introduced a new approach to building an index, better suited to informing decisions, and boosted learning through monthly meetings with City of New York agency staff during which we have discussed and obtained feedback on the methodology for developing the index.

The first contribution to improving the relevance of the vulnerability index to decisions is that the index includes indicators, which have been empirically validated as being relevant to vulnerability to flooding. The selection of indicators draws from Co-PI Madajewicz's prior research, which showed empirically which indicators are relevant to coastal flooding in New York City. Second, the index averages the indicators rather than using the common principal component approach (PCA). PCA results in an index that is difficult to interpret, and which lacks a number of desirable properties. Third, the index uses a geometric rather than an arithmetic average. The geometric average reduces the impact of a high value of a single indicator.

As part of the project, the team has begun to collect data in six neighborhoods to document determinants of vulnerability to pluvial flooding and flooding due to high tides. The analysis of indicators that are relevant to these types of flooding may modify the draft index, which is based on indicators whose relevance has been validated for storm surge flooding.

Socio-Spatial Research on Adaptation
The CCRUN social science team (Co-PI Solecki) developed a series of new partnerships this past year. These included a connection with NOAA CESSRST (Center for Earth System Sciences and Remote Sensing Technologies) based at CUNY – City College, with the National University of Ireland-Maynooth, and the Battelle Corporation (which manages the U.S. Department of Energy laboratories). These connections have enabled the CCRUN team to connect with a wider range of scientists and practitioners in a variety of other geographic contexts and transfer the lessons learned within the CCRUN region to these settings.

The team also began the analysis of the process of cascading resilience, which includes how resilience practice can spread in some cases rapidly through a community. This evaluation is designed to mirror the discussion of cascading risk. The team is looking to apply our concept to the impact of Hurricane Ida or through the analysis of a watershed in the Philadelphia metropolitan region.

Storm Surge Barriers
CCRUN (Co-PI Orton) led a scientific community effort to lay out a research agenda to study the estuary impacts of gated storm surge barriers, an increasingly common coastal flood risk reduction strategy (Orton et al. 2023).

Rising coastal flood risk and recent disasters are driving interest in the construction of gated storm surge barriers worldwide, with current studies recommending barriers for at least 11 estuaries in the United States alone. Surge barriers partially block estuary-ocean exchange with infrastructure across an estuary or its inlet and include gated areas that are closed only during flood events. They can alter the stratification and salt intrusion, change sedimentary systems, and curtail animal migration and ecosystem connectivity, with impacts growing larger with increasing gate closures. Existing barriers are being used with increasing frequency due to sea level rise. New barrier proposals typically come with maximum closure frequency recommendations, yet the future adherence to them is uncertain. Given that the broader environmental effects and coupled-human dynamics of surge barriers are not well-understood, our team presents an interdisciplinary research agenda for this increasingly prevalent modification to our coastal zone.

Also, a CCRUN student PhD dissertation project quantitatively assessed how storm surge barrier flood risk reduction efforts affect estuaries. The dissertation demonstrates a framework for assessing the estuary effects of proposed storm surge barriers using statistical modeling based on historical observations, hydrodynamic modeling, and application of future climate change projections. Moreover, these changes could amplify expected negative impacts of climate change on estuaries. The research resulted in two peer-reviewed published papers (Chen et al 2020; Chen and Orton, 2023) and one dissertation (Chen, 2022).

Urban Heat Island Mitigation

CCRUN (Co-PI Montalto) broadened our capacity to address urban heat island effect throughout the Philadelphia area through the expansion of our heat mitigation work. Piloted in the Hunting Park neighborhood of North Philadelphia, the team has expanded the installation of sprinklers and bench planters (e.g., planters with an included bench and umbrella to provide community members green, shaded places to sit in shade-deficient neighborhoods) into four additional communities in Southwest Philadelphia: Kingsessing, Haddington, Grays Ferry, and Point Breeze.

The team is particularly proud of this accomplishment because residents in southwest Philadelphia have expressed concern regarding the need for shade in their neighborhoods, as well as a lack of resources required to maintain young street trees. This project allows us to offer an alternative to street trees while still providing green spaces and shade to communities. This project also allows CCRUN to help communities empower themselves by hiring community members to construct the bench planters as well as participate in the monitoring work with various heat sensors to validate the effectiveness of the cooling strategies implemented in each neighborhood.

The following organizations participated in this CCRUN-led work; Empowered CDC in Kingsessing, Global Thinking Initiatives Inc in Haddington, Point Breeze Community Network Plus in Point Breeze, and Residents Organized for Advocacy and Direction in Grays Ferry.


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

OUTREACH AND ENGAGEMENT ACTIVITIES

C-Heat Project Outreach

The CCRUN Public Health Team (Co-PI Fabian) shared research findings from the C-Heat Project across diverse platforms, including academic conferences (Health Effects Institute Annual Conference), local conferences (Chelsea Research Festival) and local meetings (e.g., City of Chelsea Councilor Meetings). In the case of presenting at the Councilor meeting, evidence the research team presented along with community organizations resulted in the acceptance of an abandoned lot and a commitment to convert it to a community park. GreenRoots was the recipient of a CCRUN Community Grant to engage residents around park design and community needs related to extreme heat.

In addition to these events, the team boosted learning through published academic articles, presentations, Twitter posts, and a video about the Chelsea Cool Block made in collaboration with Trillium Videos. The video was shared across all our social media platforms and has resulted in over 1000 views and touted as a successful example of academic-community-city collaboration to conduct actionable research.
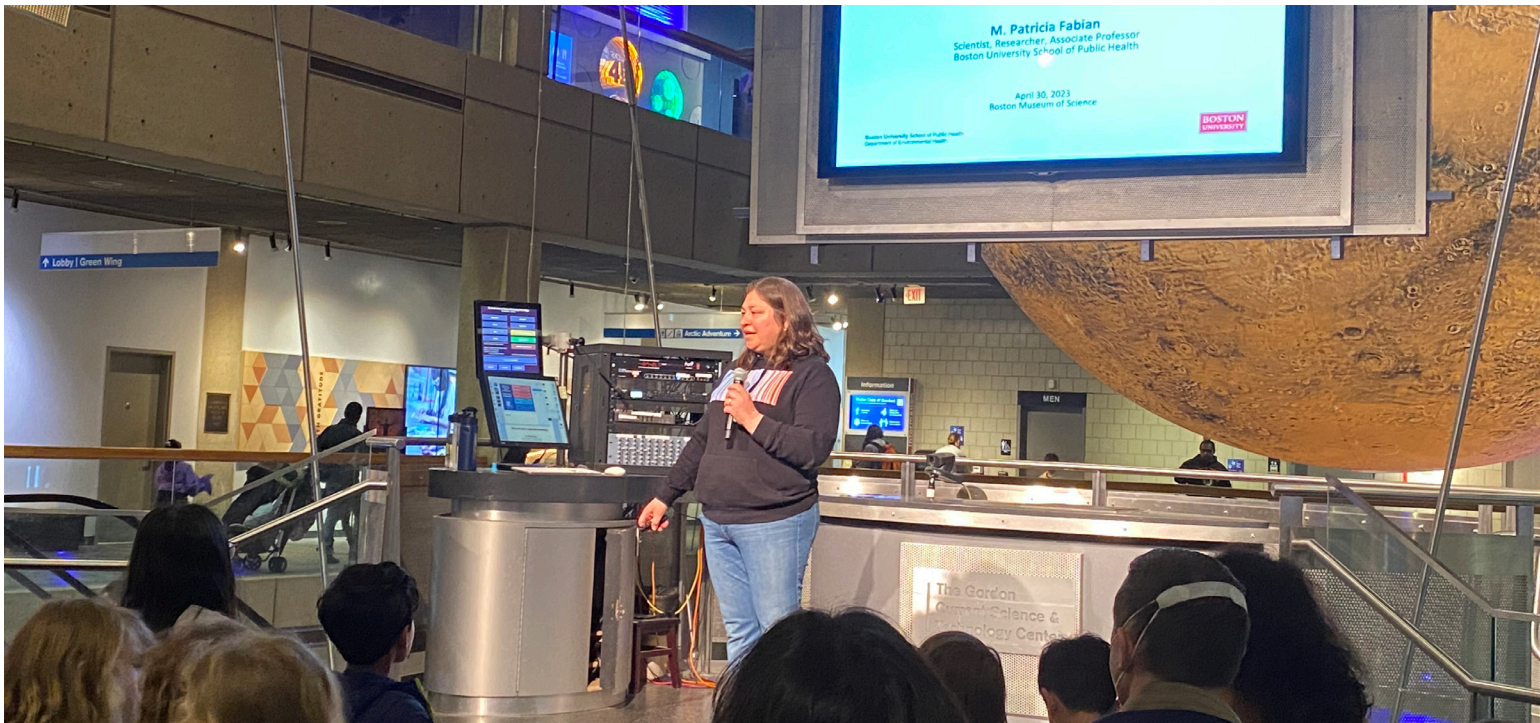
C-Heat Project Outreach: CCRUN Co-PI Dr. Patricia Fabian gives a presentation on the ACRES and C-Heat projects at the Boston Science Museum for their Rise Up for Climate event, held on April 29-30, 2023.

CCRUN 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, 6 seminars were held, topping approximately 300 attendees (an average of 50 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.

Climate Forum Series

CCRUN partnered with New York Sea Grant, New York City Emergency Management, Long Island Sound Study, New York City Department of Environmental Protection, and multiple community groups to hold climate forums in Flushing, New York on flood risk from intense rainfall events. This neighborhood of New York City features a large population of Asian-Americans and the organizers worked closely with local community members to appropriately advertise and organize the event (e.g., flyers prepared in multiple languages, translators on site during the presentations).

The first event was held on September 8, 2022, at the Chinese-American Planning Council (CPC) in Flushing, New York. The event was attended by approximately 50 people, primarily residents of the local community, many of whom came with stories about recent flood events in New York City, including the heavy rainfall from the remnants of Hurricane Ida, which caused significant impact in the neighborhood. Representatives from the offices of local government (New York City Council), the New York State Senate, and U.S. Congress were also in attendance. CCRUN's specific contribution (outside of helping with the planning) was a presentation on past, present, and future heavy rainfall and flood events in New York City. This included the latest climate science projections (which the team developed) and a discussion on the combined impacts of coastal and urban flooding. In addition to presentations, tables were set up to allow attendees to engage and learn more about flood program resources in New York City.

A second event was held on May 21, 2023, this time at the Free Synagogue of Flushing in Flushing, New York. The audience at this event was approximately 20 people, again primarily residents of the local community. CCRUN presented a similar presentation on flood risks for New York (from heavy rainfall events). Although the forum was smaller, the attendees were highly engaged and walked away with greater knowledge on flood hazards and resources in New York City. The presentation by New York City Emergency Management, a long-time CCRUN stakeholder, walked the group through the steps they can take prior to, during, and after a flood event.

Prior climate forums, co-organized by CCRUN and New York Sea Grant, were focused on coastal flood risk, primarily along the southern part of New York City. With these new events, a new climate hazard was the focal point, and these were the first workshops held in the northern part of Queens. CCRUN is looking forward to hosting more of these events in the future.

Coastal Communities Workshop

CCRUN (Co-PI Solecki) hosted the workshop "Promoting Effective Resilience Strategies and Programs in Coastal New Jersey-New York Communities: A Continuing Dialog and Assessment of Emerging Needs" in September 2022. At the workshop, the team presented the results of our survey work in New Jersey and New York. The workshop was attended by coastal resilience practitioners and policy makers in the region. The results were well appreciated and integrated into the decision processes and practices of those individuals attending. The workshops boosted **learning outcomes** and resulted in a **deeper understanding of science** or local knowledge related to climate, impacts, and adaptation, and the work **shifted mindsets**, resulting in documented cases of new readiness to act or acceptance of a need to act. This was specifically achieved by illustrating how and to what extent coastal resilience practices were being taken up and implemented by households in the region's coastal communities. This analysis surrounding conditions of engagement helped bridge the knowledge gap between government practitioners and at-risk communities regarding adaptation and resilience measures post-disaster.

Community Workshops in Philadelphia

CCRUN has participated in community outreach with frontline and underserved communities (e.g., heat stressed communities throughout Philadelphia, specifically Hunting Park, Kingsessing, Haddington, Grays Ferry, and Point Breeze) in the expansion of our heat mitigation work, touched on earlier in this report. We have also engaged with the Eastwick community in southwest Philadelphia, as well as Camden, NJ in our flood mitigation work.

NPCC and NYSCIA Workshop

A two-day workshop was held in June 2022 to coordinate efforts between the New York State Assessment Climate Impacts Assessment (NYSCIA) and New York City Climate Vulnerability, Impact, and Adaptation Analysis (VIA) project. The workshop was attended by VIA project team members, members of the NPCC, representatives from New York State and New York City.

CCRUN scientists working on the climate science task of the project helped co-organize the workshop and led multiple presentations over the course of the event. One of the primary objectives of the meeting was to ensure that the climate risk information being used by both the City and State is coordinated and consistent. A secondary objective of the meeting was to have subject matter experts present on the state-of-the-science for a variety of climate hazards impacting New York State, including New York City. Presentations covered topics such as the updated climate science projections using CMIP6 model data, sea level rise projections and methodologies and climate extremes and storms, and compound extreme events. The science presented at the workshop is being shared (and utilized) by the full VIA project team.

CHALLENGES

Challenges that Communities Face in Engaging in Adaptation to Flooding

Most community organizations are run by volunteers who have full time jobs and families to take care of. Adaptation planning, funding, and implementation are complex tasks, which require time and resources. In addition, underserved communities in a large city like NYC do not have their own municipal institutions, which they would need to apply for FEMA flood mitigation grants. Building the capacity of these communities to plan and fund adaptation is an important agenda for future research.

Setting of Small-Grants Competition Projects

The launch of the small-grants competition was delayed as it took longer than anticipated to bring onboard the community group partners. This was in part caused by the fact that the types of organizations selected to participate require a separate process that requires additional effort as compared to a more traditional subaward with an academic partner. Working together, all challenges were overcome and should CCRUN choose to bring on additional community groups in the future, our team now has the experience to do so more efficiently.

Staffing Changes

CCRUN also experienced a significant staffing change during the reporting period, as our website designer had to abruptly stop working. This left the team with limited capacity for website updates, social media posts, and other graphic design tasks for project communications. Our team is looking to hire a new team member to fill this role as soon as possible. Fortunately, the content management system used by the existing website still allows the core project team to make critical updates to the website while looking to make a hire.

PLANNED ACTIVITIES

2023 Managed Retreat Conference

In June 2023, Columbia will for the 3rd time host a global conference on Managed Retreat. CCRUN will be a primary partner, and there will be NOAA participation, as well as numerous panels featuring speakers from other parts of the federal government including FEMA and CEQ. The conference will span 3.5 days and feature close to 500 in person attendees and over 100 remote attendees. Key themes include:

- 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.

Climate Action Plan for Jacob K. Javits Convention Center

CCRUN (Co-PI Montalto) is planning to expand our work at the Jacob K. Javits Convention Center in New York City. Next steps include a plan to monitor the water and energy balance of the Convention Center green spaces, including the orchard/food forest, pollinator meadow, shade garden, food cropped area, and the north and south green roof.

Also planned is the development of a

Green Roof Monitoring: CCRUN researchers (including co-PI Dr. Franco Montalto) conduct a tipping bucket test for rain gauge installed on one of the green roofs at the Javits Convention Center in New York City.

comprehensive Climate Action Plan for the Javits Center, quantifying specifically the offset emissions associated with onsite food production, onsite renewable energy production, and other innovative sustainability and climate mitigation scenarios for a facility of this type.

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 has a proposed project which will assess tradeoffs between approaches to adaptation in four case study communities, two on Long Island and two in coastal Virginia. The objective of the planned research is to co-develop with the communities a decision support framework that can help to select flood adaptation options, which can most effectively achieve the communities' objectives. The framework will be applicable beyond the study communities, along the Atlantic coast. As one of the first objectives of the proposed work, the team plans to document the baseline vulnerability conditions in the study communities and to begin workshops, in which we will use mental modeling to co-develop an understanding of current and future vulnerability to flooding, and to begin assessing different adaptation options.

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. Decision makers include practitioners and policymakers from public, private non-profit, and private for-profit sectors, and representatives of community groups.
- 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 experience with using the research results 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 engagements. We are also documenting awareness, climate impacts, recovery, and adaptation actions specifically in the context of flooding 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 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 a project funded by the City of NY, Vulnerability, Impacts, and Adaptation (VIA), by collecting data on vulnerability and adaptation to pluvial and tidal flooding in six different neighborhoods of NYC. The purpose of the data is to validate indicators for the NYC flood vulnerability index; however, the data will also serve as baseline for assessments of changes in resilience and adaptation over time.

Another type of baseline data that the team has collected documents 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 over time as new climate events occur and new adaptation initiatives are implemented, comparing the large urban metropolis of NYC to evolution of adaptation 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 a proposed to start a new project, which would combine ex ante and ex post methodologies to assessing the effectiveness of a decision support framework 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. A new project proposed to start in September, is specifically designed to compare the effectiveness of the decision support framework mentioned above across four study sites, which have strategically selected differences in environmental, socioeconomic, and governance conditions. Another continuing challenge is the availability of appropriate data for evaluation and resources to collect appropriate data.

EVIDENCE OF SOCIETAL IMPACT

C-HEAT Project
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. Some accomplishments in the last year include:

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.

The work on the C-HEAT project has also elevated a **sense of agency** of Chelsea and East Boston residents through a Photovoice research project which identified calls to action around tree equity, access to water, population vulnerability and keeping cool creatively. Community calls to action were shared at a public event at City Hall. Photos and bilingual captions were displayed over 6 weeks inside City Hall and on banners in parks around East Boston and Chelsea. The public display of this information can improve citizens **learning** about climate impacts and adaptation.

Climate Resilience Research Agenda for Philadelphia
In May 2023, CCRUN (led by Co-PI Montalto), in partnership with the Delaware Valley Regional Planning Commission, the Academy of Natural Sciences, and the City of Philadelphia Office of Sustainability, launched the finalized Climate Resilience Research Agenda (CRRA) for the Philadelphia region. The CRRA is a co-produced preliminary list of research activities that, if undertaken, could help to make the Philadelphia region more resilient to climate change.

The launch of the report culminates a multi-year effort that began in 2021, when the group convened more than 100 researchers, community members and stakeholders to produce a research agenda. The plan focuses on four key areas, which were the themes of each of the working group's that participated. They are:

- Cascading climate hazards
- Health and environmental vulnerability
- The built environment and infrastructure systems
- Regional climate governance and adaptive management

Rather than a traditional focus on climate mitigation or climate adaptation, Working Group members deliberated more broadly about how climate action could be integrated into decisions, policies, and strategies that could collectively make the region more resilient to climate change. This new approach is an example of increasing the **flexibility** that our partners have to responding to weather and climate risk. A **learning outcome of the** the process of bringing together such a diverse group of academics, practitioners, and other experts is a robust report that deepens the understanding of science and local knowledge related to climate, impacts, and adaptation.

The research activities featured in the CRRA constitute a first step in what must become an ongoing, inclusive public discussion regarding how this region will address the challenges of climate change. The CRRA intends to provide important context for decision-makers and policymakers, practitioners, philanthropic organizations, community-based organizations, and others as they incrementally work to make the region more climate resilient. The report lays the foundation for future work, as the **ability** for partners (existing and new) to **self-organize** is established in the agenda.

In addition to the research steps, the CRRA includes updated climate projections for the Philadelphia region, developed by the CCRUN climate science team (Lead-PI Horton). The projections are for temperature, precipitation, and sea level, and include mean changes and changes in extreme events, such as hot days, heatwaves, and days with extreme precipitation. This climate risk information increased the **assets**, in the form of data, available to regional stakeholders.

Since the reports launch (in the final days of the reporting period), there has already been a significant amount of local media that has highlighted the effort and outcomes.

Evaluation of the Co-Production Process
Co-PI Madajewicz is in the process of completing the evaluation of the co-production process, which the team undertook to build capacity to adapt to flooding in coastal communities in the Rockaways in New York City. The purpose of the evaluation is to identify lessons that can be applied to building capacity in other coastal communities. The collaboration with communities resulted in the co-development of very different information than had been disseminated to communities through various outreach efforts undertaken since Hurricane Sandy.

The outcomes that resulted from this new information include a substantial **shift in residents' mindsets** toward taking adaptation action. Attitudes changed from disengagement, a perception that there were no actions that residents could take given their available resources, and that adaptation was the responsibility of government to a **sense of agency and urgency**, a perception that residents both can and must take action as soon as possible. The initiative boosted **learning outcomes**, improving residents' understanding of risk and quantitative benefits of adaptation, estimated as the reduction in future flood recovery costs that residents could achieve with a range of different adaptation actions, at the level of their individual homes and families. Understanding their individual situations led participants to engage with the adaptation problem, to recognize that all residents need this kind of information, and to consider how to begin processes of collective, community-level planning. The initiative increased **flexibility**. Participants found the menu of available adaptation options and the idea that different actions were appropriate for different households particularly empowering. Unlike actions recommended by previous outreach efforts, they could find actions that are feasible for them in the broader menu.

The evaluation also identified evidence that behavior was beginning to change even within the short term of the evaluation, which covered only one year after the intervention. The project helps **build assets** by providing community groups and residents with the 'Rockaway homeowner's guide to preparing for flooding,' an online story map, which can support adaptation decisions and guide community-level planning efforts.

COMMUNITY CLIMATE RESILIENCE GRANT COMPETITION

CCRUN launched its inaugural small grant program, the Community Climate Resilience (CCR) Grant Competition, in the summer of 2022. Fours programs have been funded with one-year grants of $25,000, with projects set to conclude in January of 2024. The program was designed with multiple dimensions of equity—particularly distributional, procedural, and contextual equity—in order to build capacity and advance the sense of agency of partners in frontline and underserved communities in the urban Northeast.

Selection Process

The initial call for proposals (CFP) was released on our website and social media and sent around via email to a listerserv of community-based organizations (CBOs) working on climate or environmental justice and resiliency in the region on May 12, 2022. The listserv was developed with input from the entire CCRUN team and included CBOs that have worked with CCRUN in the past and potential new partners. CCRUN team members were asked to distribute the CFP to relevant listservs at their institutions and other networks. The CFP included available service categories where CCRUN researchers could offer specific expertise to co-develop research and support applicant projects.

An informational webinar was hosted on May 24, 2022, where interested applicants were able to meet the CCRUN team, learn about the program, and ask questions about the application requirements, including CCRUN service categories. Letters of intent (LOI) were requested from all interested applicants on June 20, 2022. LOIs required organizations to submit their 501(c)(3) status, a brief description of their intended project or topic to be addressed, and selection of a service category. The purpose of the LOI was to screen applicants for their tax status to ensure both CCRUN's ability to fund each group through university funding structures and the applicability of projects proposed for CCR program goals, in order to limit the time of CBOs spent applying if projects were not appropriate.

LOIs were evaluated by a committee within CCRUN using a rubric to rate budget and timing feasibility and potential for meaningful environmental justice and climate resiliency outcomes. Fourteen of 23 applicants who submitted LOIs were invited to submit full applications. Full applications required a complete project description, including project goals, a work plan, description of stakeholders and community partners, anticipated data needs, a description of the project team, and a budget with a justification.

Thirteen applicants submitted full applications on August 1, 2022. Full applications were first evaluated by an internal CCRUN committee using a rubric assessing overall proposal quality and environmental justice relevance. Results from the rubric were sent to the full CCRUN team for final discussion and selection of grantees, which included prioritizing geographic diversity across the CCRUN region, and expertise and availability of CCRUN researchers to support project development.

Community Partners and Planned Activities

Four applicants were selected to receive $25,000 one-year grants on September 2, 2022: Eastwick United CDC in Philadelphia, PA, Groundwork Elizabeth in Elizabeth, NJ, Groundwork Hudson Valley in Yonkers, NY, and GreenRoots in Chelsea, MA. While the grants are small, the CCR program was designed to increase the **flexibility** of our community partners in developing existing projects and launching new initiatives. Each organization has partnered directly with a member of the CCRUN research team who works collaboratively with the grantee to support implementation of their projects. Eastwick United CDC is partnering with Co-PI Franco Montalto to develop a conceptual land-swap plan utilizing data developed at Drexel University's Sustainable Water Resource Engineering Lab in order to inform a report prepared by the Urban Land Institute's (ULI) Technical Assistance Program (TAP) for inclusion into a BRIC application for FEMA and PEMA. Groundwork Elizabeth is partnering with Co-PI Robin Leichenko and Senior CCRUN Personnel Jeanne Herb and Marjorie Kaplan to form an action committee examining environmental hazards at a local tributary, develop a tree management and native species plan, and plan for long-term community engagement with climate issues in a local park. Groundwork Hudson Valley is partnering with Co-PIs Malgosia Madajewicz and William Solecki to support the development and implementation of the Climate Action Plan in the City of Yonkers through community engagement and capacity building campaigns. GreenRoots is partnering with Co-PI Patricia Fabian to further their Cool Block strategy program, including transforming a vacant lot into a green space demonstration project and a community engagement campaign to connect at-risk residents with local cooling solutions.

CCRUN is organizing quarterly meetings with all grantees and co-PIs to discuss project status including best practices and challenges. The meetings have provided the opportunity to form a regional community of practice in support of collaborative **learning** among CBOs focused on building resiliency and advancing climate justice in the Northeast.

CCR Grantee Partner Groundwork Elizabeth's Earth Day Celebration (April 2023): Groundwork Elizabeth's team helped community members and local students plant native tree species along the banks of Trotters Branch of the Elizabeth River in Phil Rizzuto Park to prevent further erosion of the stream bank.

Expected Outcomes

All grantees completed a pre-grant survey before beginning work to share their thoughts on the application period, as well as to identify their own measures of success for their projects. Following the grant period, all grantees will complete a post-grant survey to report their accomplishments and to compare them with their initial expectations. Our decision to have grantees develop metrics of their own success instead of being externally evaluated with standardized rubric furthers our commitment to co-production of research, as well as reducing the burden on community organizations and maintaining **flexibility** in our relationships.

Grantees will also provide project status updates in brief reports at the midpoint and conclusion of the grant period. They will report **learnings** from their projects via blog postings on the CCRUN website and during a webinar that will be held in early 2024. Additional information about the CCR Grantees and their projects is available on CCRUN's website: **www.ccrun.org/ccr**.

Products and Presentations

As part of the CCR project, CCRUN partnered with the NJ Climate Change Resource Center based at Rutgers University to develop a database of climate tools for the region, in an effort to create an **asset** that strengthens access to climate planning tools and datasets in the region. Graduate student Josephine O'Grady with the Center's Climate Corps produced the database and shared it with grantees during a quarterly community of practice meeting, which generated interest in the tool and led to conversations about other necessary data sources and use-cases.

Co-PI Robin Leichenko and graduate student Katherine Cann presented the initial work of the CCR Program during a panel and a paper session at the American Association of Geographers meeting in Denver, CO in March 2023. The sessions generated interest in the creation of a national community of practice with other CAP researchers working on equity and co-production of climate services, including work on CAP small grant programs.

Challenges and Lessons Learned

One notable challenge we have confronted during program implementation is burdensome paperwork requirements for community partners to receive the funding through university pass-through structures. Community partners have expressed concern over standard intellectual property language in university contracts, raising important questions about how the structure of pass-through funding can restrict the **sense of agency** and autonomy of CBOs and ownership of local knowledge. Similarly, reimbursement requirements may place an undue burden on organizations with limited budgets, forcing grantees to pay for their work upfront before receiving grant funding. Additional challenges include significant time commitments and funding limitations for both the CCRUN researchers and CBOs to participate in the community of practice—necessary work for successful co-production. Due to the limited resourcing from small-sized grants, CBOs are not able to fund an entire salary with the sum, therefore finding time to attend regular meetings can present a challenge. The limited size of the grants also impacts our ability to offer the data that the organizations are requesting in some cases (e.g., one project partner requested new collection of local flooding data).

Though we are still in the middle of the program, we have found the regional community of practice meetings to be extremely valuable for our grantees who have shared meaningful stories and challenges about adaptation in their respective cities. We hope this community of practice leads to **self-organization** of further collaborative opportunities between partner organizations. Additionally, our grantees have hosted exciting community meetings and events, including a community Earth Day celebration and tree planting event hosted by Groundwork Elizabeth, which significantly furthered their project goals of forming a community resilience task force and planting and maintaining trees to prevent erosion on their project site. All projects are progressing and the CCR program is measuring some initial successes in forming deeper connections between CBOs and CAP researchers working in the region.

APPENDIX A. CCRUN PUBLICATION LIST

Peer-Reviewed Publications

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