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Volume 14 | Issue 1 Article 4

2021

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Recommended Citation

Campbell, Lindsay K., Cheng, Helen, Svendsen, Erika, Kochnower, Dana, Bunting-Howarth, Katherine and Phoebe Wapnitsky. 2021. "Living with Water: Documenting lived experience and social-emotional impacts of chronic flooding for local adaptation planning," Cities and the Environment.

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Living with Water: Documenting Lived Experience and Social-Emotional Impacts of Chronic Flooding for Local Adaptation Planning

Coastal communities are threatened by extreme weather events in the form of storm surge and by frequent, chronic, or nuisance flooding. The physical damage of these events is vast and established in the literature; however, the social-emotional impacts are less well-documented. This pilot study sought to understand the impacts of tidal flooding on flood-prone communities in Queens, NY. Through in-depth, semi-structured interviews (n=9) with civic science participants, we document flooding impacts, identify adaptations to flooding, and examine sources of information about flooding--including local networks and relationship to government. We found that participants are knowledgeable about and engaged with the processes, rhythms, and impacts of tidal flooding. Qualitative methods can be used to surface experiences of living with flooding and therefore inform planning processes. This work demonstrates the need to attune methods and data collection to better capture and understand lived experience, local ecological knowledge, and civic engagement--as these are crucial building blocks for strengthening social resilience. Finally, by rooting the research in civic science and a co-production approach, this study provides a starting point for building shared knowledge across different stakeholders to inform collaborative adaptation planning. Ultimately, we seek to better engage local knowledge -- including rich, qualitative data capturing lived experience -- into adaptation and resilience planning.

Keywords

chronic flooding, social impacts, community resilience, adaptation planning, civic science

Acknowledgements

We would like to thank all of the NYC Community Flood Watch Program civic scientists, interviewees, and organizational partners for their engagement in the program and this study. This work was supported by the Science and Resilience Institute at Jamaica Bay, New York Sea Grant, the NYC Mayor's Office of Resiliency, and the USDA Forest Service Northern Research Station. Particular thanks to Katie Graziano, Michelle Johnson, and Carrie Grassi for their review and input on earlier drafts of this manuscript.

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This article is available in Cities and the Environment (CATE): https://digitalcommons.lmu.edu/cate/vol14/iss1/4

INTRODUCTION

Coastal communities face challenges in understanding, preparing for, recovering from, and adapting to flooding. Communities are threatened by extreme weather events in the form of storm surge, nor'easters and hurricanes, but also by frequent, chronic or nuisance flooding during astronomical high tides. Referred to as "sunny day" or "high tide" flooding, this occurs when the sea comes overland at low-lying street ends or surcharging through sewer infrastructure (Sweet et al. 2020). The impacts of catastrophic, one-time coastal disasters, such as 2012 Superstorm Sandy, are well-documented (see, e.g. Blake et al. 2013; Rosenzweig and Solecki 2014; Lieberman-Cribbin et al. 2017). But chronic stressors, such as monthly spring tides and heavy rainfall, also are increasingly causing damage in the form of flooding in low-lying waterfront neighborhoods. According to a technical report released by National Oceanic and Atmospheric Administration (NOAA) National Ocean Service, locations across the U.S. Northeast saw 100-150% more flood days in the year 2019 than in 2000, and these events are happening during times of sunny, blue-sky days, and not including days with storms also likely to see flooding (Sweet et al. 2020). This nuisance flooding affects mobility and transportation, damages property, impacts local economies, and affects human and ecological health (Andreucci and Atkas 2017; Jacobs et al. 2018; Hino et al. 2019). Climate change is not a future state, but is a current condition having major impacts, particularly in coastal communities. There is a need to learn from and work with these frontline communities to support their ability to adapt to living with water.

Coastal cities, with hardened shorelines, vast areas of impervious surface, and dense populations are particularly vulnerable. In New York City (NYC), sea level rise and an increased occurrence of high-intensity rainstorms induced by climate change, have led to a dramatic increase in flood risk, particularly in low-lying and coastal neighborhoods (Talke et al. 2014; Orton et al. 2019). While catastrophic flooding events associated with large storms like hurricanes and nor'easters gain great attention, some people's lives are often disrupted by smaller, more frequent street-level floods accompanied by extreme high tides and high-intensity rain events. In 2019 alone, 3,221 calls were placed to NYC's 311 service request portal for complaints of street-level flooding (NYC Open Data 2021). Standing water on streets and sidewalks can damage infrastructure, impede mobility, and create financial costs and emotional stress for visitors and residents (Christie et al. 2016). With projected sea level rise across the Northeast U.S., the frequency of high tide flood events could increase 5 to 15-fold by the year 2050 (Sweet et al. 2020). Despite the growing risk and occurrence of urban floods--including events tied to both rainfall with sewer surcharging from high tides and coastal surge, state and federal governments do not track hyper-local urban flooding over time, and there are limited data available on the precise location, frequency, extent, and depth of these floods (University of Maryland 2018), as well as their social impacts. We argue that, in aggregate, these frequent street-level flooding events are in themselves natural disasters with chronic social impacts and critical data limitations that inhibit the informed development of resiliency plans, infrastructure upgrades, and forecasting systems.

While models and projections are able to demonstrate the extent of flooding in an area, they do not provide the hyper-local, temporally specific resolution of the impact on a community and its residents, nor do they reveal how these events impact the social-emotional well-being and

livelihoods of residents living in coastal areas vulnerable to high-tide flooding. There remains a need for a dataset of observed current high tide driven flooding, along with social-emotional impacts on residents' ways of life, that can validate projections and inform adaptation planning. In order to devise feasible adaptation solutions, it will be necessary for government agencies, community groups, and local residents to build trust, more effectively communicate, and coordinate their efforts. These data can often be qualitative in nature (i.e. stories, narratives, first-hand accounts), yet can be integrated with quantitative data and tools to be used by local government and the community to produce ancillary benefits.

Multiple forms of engagement between community residents and local government can inform research and improve adaptation planning--with approaches ranging in intensity from consultation and contribution, to collaboration, to full co-production of knowledge (see, e.g. Shirk et al. 2012; Silva and Krasny 2014). Specifically, civic or community science can help fill data gaps by using local knowledge, including local ecological knowledge, to inform decision-making (Charles et al. 2020). Local ecological knowledge is defined here as "knowledge, practices, and beliefs regarding ecological relationships that are gained through extensive personal observation of and interaction with local ecosystems, and shared among local resource users." (Charnley et al. 2008, p.2). Where interested members of the public are engaged in sharing and creating knowledge, civic science is a way to strengthen relationships, credibility, and trust between data providers and end users that supports the creation of useful information products (see, e.g. Cash et al. 2003; Kuonen et al. 2019). For example, NYC Community Flood Watch in New York, NY is a civic science initiative to document and report flooding in communities and build relationships among residents, researchers, emergency managers, and public agencies to improve awareness of and response to flooding in vulnerable coastal communities (https://www.srijb.org/jbfloodwatch/).

While civic science data have been gathered on the timing, location, and depth of flooding as part of NYC Community Flood Watch there is a dearth of information about the lived experience of chronic flooding. This pilot study, an extension of NYC Community Flood Watch, sought to understand the scope of physical, social-emotional, and economic impacts of tidal flooding on flood-prone communities in Queens, NY in order to inform adaptation planning through community engagement as well as the further expansion and refinement of the civic science program itself. We posed the following overarching research questions: What are the social impacts of living with chronic flooding? How can we use qualitative methods to capture both subtle and sustained changes and impacts? How are communities already adapting to "living with water" and what further adaptation strategies can the city and community use to best limit negative impacts? Through in-depth, semi-structured interviews (n=9) with NYC Community Flood Watch participants, we document historical and current living conditions, perceived change to living conditions due to flooding events, adaptations to changing conditions, and residents' visions of their mid-term futures (i.e.10 year horizon). The focus of this study is not on large-scale measures such as coastal retreat; instead we identify city services or operations that are currently affected to inform potential low-cost adaptations and operational changes that can address residents' challenges. This project was co-produced by researchers and practitioners working across academia, local government, and boundary organizations committed to advancing usable science. As such, we aimed to develop and refine a replicable method with trust and engagement from all of these parties. Ultimately, we seek to better engage local

knowledge--including rich, qualitative data capturing lived experience -- into adaptation and resilience planning.

SOCIAL AND EMOTIONAL IMPACTS OF CLIMATE CHANGE AND FLOODING

Climate change and flooding pose critical risks to the holistic wellbeing of communities, particularly the most vulnerable or marginalized members. Social vulnerability influences coping, adaptation, and resilience in the wake of a natural disaster (Lowe et al. 2015). According to the American Psychological Association (APA 2017), negative consequences of climate change disproportionately impact Indigenous communities, communities of color, coastal areas, migrants, and refugees. Rufat et al. (2015) evaluated factors associated with social vulnerability to the consequences of flooding through a meta-analysis of 67 flood disaster case studies, finding socioeconomic status, social determinants of health, and risk perception of flood events as primary influences to flood vulnerability. Numerous, intersecting characteristics are associated with social vulnerability, including coping capacity, demographics (including lingual and cultural factors), health status, land tenure, neighborhood characteristics, and socioeconomic status. There is high-risk vulnerability for populations with extensive service needs, including nursing home residents, chronically ill individuals, groups requiring continuous care, and homebound residents (Rufat et al. 2015). Bukvic et al. (2018) describe the vulnerability of older populations, which are unevenly distributed in the 271 coastal counties of the U.S. East Coast, with an average 15.4% of the population being 65 years and over. Many places with larger, older populations often also have aging housing infrastructure. In addition, physical disabilities or challenges with access to technology can limit older adults' ability to receive and/or meet their health services and needs. During a disaster event, physical disabilities can affect engagement in preparedness activities, evacuation, and impacts in the aftermath. In the context of recurrent flooding, dealing with repetitive damage, loss of belongings, changes in the demographic community profile, restricted accessibility to gathering places, and other chronic flooding impacts can all affect the well-being of older coastal residents (Bukvic et al. 2018). According to the Center for Energy and Environmental Research in the Human Sciences (2017), structural and social dimensions of vulnerability to flooding, including race, ethnicity, socioeconomic status, and immigration status, also influence capacity to prepare for future flooding events. Other specific vulnerable sub-populations of concern include incarcerated populations (Montanya and Valera 2016) and LGBTQ+ populations—for example, because diverse, queer household structures are not always recognized as part of formal, disaster recovery processes (Dominey-Howes et al. 2014, 2018). Overall, it is important to consider the ways in which multiple dimensions of identity intersect to produce risks, vulnerabilities, yet also novel sources of social resilience.

Natural disasters are "ecological and economic catastrophes" and "social and psychological catastrophes" (Knez et al. 2018, p.11). Increases in global climatic extremes are associated with physiological, psychological, and social health consequences. The APA found a wide range of negative implications of climate change upon individuals, communities, and globally, including an association between children's development of obsessive-compulsive behaviors and severe posttraumatic stress symptoms (APA 2017). Chan and Rhodes (2014) evaluated the longitudinal social impacts of exposure to Hurricane Katrina, finding that exposure to the natural disasters, severity of exposure, inaccessibility to basic needs, including medical

care, food, water, and shelter; structural factors, such as race and ethnicity; and loss of a pet during the event were strongly associated with development of Posttraumatic Stress Disorder (PTSD) and general psychological distress. Directly experiencing the consequences of climate change and natural disasters are associated with acute development of PTSD and other anxiety disorders (Padhy et al. 2015). Hammond et al. (2015) evaluated risk factors for development of PTSD and related anxiety spectrum disorders, finding the greatest risk factor for PTSD development is extent and frequency of flood exposure.

The mental health impacts of environmental degradation are evident. Solastalgia is the "…loss of solace that occurs with environmental degradation" and encompasses sentiments of ecological grief experienced following natural disasters (Padhy et al. 2015, p. 5; see also Albrecht et al. 2007). For example, surviving a wildfire can be a psychologically distressing experience, with "…property damage, life endangerment, and physical injury…" being pertinent predictors of behavioral and psychological health outcomes following the event (Eisenman et al. 2015, p. 603). A community's surrounding ecosystem and environmental features are highly impactful upon biological, psychological, social, and economic protective and risk factors. When individuals are impacted by extreme events and related disturbances, there is an association between one's experience and the likelihood of developing chronic stress disorders. This experience can extend to holding negative perceptions about place and one's place-identity. When place-identity is disrupted following a natural disaster, negative cognitive, psychological, and behavioral health consequences may surface. Key mitigating factors in reducing the occurrence of stress disorders include socioeconomic status, access to social support services and less visual damage to place (Van der Linden 2014; Eisenman et al 2015; Knez et al 2018).

IMPACTS OF CHRONIC AND NUISANCE FLOODING

In addition to the well-established research on ramifications of flooding from extreme events, a growing literature is identifying the impacts of chronic and nuisance flooding. First, during tidal flooding events, roads may become impassable or not safe to drive on, affecting transportation and routine or emergency services and needs. In the U.S. East Coast, tidal nuisance flooding affects over 7500 miles of roadways, possibly causing delays exceeding 100 million hours annually (Jacobs et al. 2018). The Federal Highway Administration (FHA) requires state Departments of Transportations (DOTs) to set targets for alleviating congestion and delays; however, increasing hours and days of nuisance flooding may be at odds with these targets (Jacobs et al. 2018). Not only does flooding impact the use of roadways, but it also makes them vulnerable, requiring more maintenance and repair. The FHA says that state DOTs should address future impacts on roadways and address more than just condition targets, accounting for climate change in assessing the performance and investment needs and lifetime of a vital highway or roadway (FHA 2017).

Second, nuisance flooding and inundation creates economic impacts, including damages to residential property and disruptions to local economic activity. According to one study, cumulative land inundation in seven coastal Connecticut municipalities was calculated as 15 to 25 km^2, while direct economic costs to residential property estimated to be $1.3 billion and $2.2 billion for 1- and 2-meters sea level rise, respectively (Andreucci and Aktas 2017). Sunny day high tide flooding is episodic and often particular to place and is therefore challenging to assess

its full impact on the community. Reliance on a variety of data sources (i.e. eye-witness accounts, photographs, video analyses, social media) is critical in understanding the full range and degree of impact of flooding. Hino et al. (2019) analyzed these data sources for Annapolis, Maryland, a popular coastal tourist destination, but also an area that is experiencing sea level rise at a rate two to four times greater than the global mean and setting records for high tide flooding (Sweet et al. 2020). As floods became more severe in the main tourist area of Annapolis, visits fell further. With one foot of sea level rise, the area would experience an estimate of 24% fewer visitors than in a year without high tide flooding (Hino et al. 2019).

Finally, chronic flooding can impact both ecological and human health. In terms of ecological impacts, saltwater intrusion due to sea level rise and frequent flooding threatens freshwater aquifers for drinking water (Vineis et al. 2011). Saltwater intrusion can severely affect land management and ecosystem services in the form of coastal forest loss, wetland loss, and agriculture crop yield decline (Tully et al. 2019). The effects of a single flash flood event in an urban area can be far more than detrimental as its impacts affect people living in a densely populated area both directly and indirectly as a result of critical infrastructure failures (Klinger and Landeg 2014). Many of the health effects that Bell et al. (2018) identify from frequent and heavy rainfall events also apply to frequent flooding, such as mold growth and increase in other aeroallergens that trigger allergic rhinitis and asthma. Additionally, frequent flooding events and rising sea levels associated with climate change can lead to increases of disease from arboviruses carried by vectors such as the transmission of salinity-tolerant mosquito vectors and mosquito-borne diseases in coastal zones as habitable environments are altered (Ramasamy and Surendran 2012).

BUILDING COMMUNITY ADAPTIVE CAPACITY THROUGH SOCIAL SUPPORT, CIVIC SCIENCE, AND KNOWLEDGE CO-PRODUCTION

Social support--including through neighborhood networks, organizations, and civic engagement--is crucial to adaptive capacity and building resiliency. While there are numerous definitions of social resilience, we focus on "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change" (Adger 2000, p. 347) Lowe et al. (2015) assessed resilience in low-income mothers who are survivors of Hurricane Katrina, finding associations between increased capacity for resilience and experiencing relatively stable childhoods and preexisting social support, such as healthy intimate partnerships and community ties, religiosity, and economic mobility. Improvement from pre- and post-disaster distress was possible if the participants had access to at least one stable, supportive personal relationship. Manove et al. (2019) evaluated posttraumatic growth in the aftermath of Hurricane Katrina and found that community engagement processes, social support, and a 'robust gratitude for life' among local residents all significantly strengthened coping skills (p. 192). Similarly, following Hurricane Harvey, Houston residents found solace in active and meaningful civic engagement that took place during the recovery phase of this disaster (Center for Energy and Environmental Research in the Human Sciences 2017). Communities with stronger ties and better channels for information sharing tend to be more prepared to withstand and recover from natural disasters and their health impacts (Paton and Johnston 2001; Thornley et al. 2015; Klinenberg 2015; Ludin et al. 2017).

During times of acute and chronic disturbance, activities and organizations that help restore social and environmental connections have strengthened social resilience (McMillen et al. 2016; Campbell et al. 2019). These activities include stewardship activities and civic science programs that foster social trust, connectivity, and knowledge co-production. Here, we define co-production as the production of knowledge across different domains (researcher, practitioner, community member) and ways of knowing (scientific method, lived experience, local ecological knowledge) that is often facilitated by boundary organizations or participatory research processes (Guston 2001; Minkler and Wallerstein 2008; Berkes 2012; Campbell et al. 2016). Civic science is one participatory approach to producing knowledge across domains of difference that can range in its degree of engagement and power sharing – from contractual, to contributory, to consultative, to collaborative, to co-produced, to collegial (Shirk et al. 2012; Silva and Krasny 2014). Civic science efforts around flooding often value local community knowledge, aim to support residents susceptible to flooding, provide education on mitigation efforts, enhance local ecological and scientific knowledge, and seek to strengthen community preparedness and resilience and involvement in local planning (Bonney et al. 2009; Conrad and Hilchey 2011; McGinnis and McGinnis 2011; Reges et al. 2016; Yang et al. 2018). Civic science programs not only help to grow an active, engaged populace with greater awareness of flooding and climate change and build community resilience, but can also sensitize and shift government approaches to be better adept at working with local residents, to take in new information from the ground-up, and to co-produce solutions.

Research can inform policies and resilience plans that are seeking to increase and amplify voices of marginalized populations who are disproportionately affected by climate change. Kemp and Palinkas (2015) suggest recommendations for practitioners, policymakers, and community leaders to recognize epidemiological impacts of climate change, promote physical and psychological well-being; foster community social support; and enhance individual and community resiliency and coping skills in the face of climate change. Ramasubramanian et al. (2016) note, "Community resilience also requires that government actively support empowered community participation for several reasons 1) better understand needs of the community ...about the systems of hazards in question…. 3) to educate the community 4) to promote the capacity for community self-organization 5) to satisfy other values that are distinct from sustainability-resilience.... Responding in the moment requires the knowledge initiative and action of everyday people, not just the expert and the official." (p. 250). Oftentimes, vulnerable flood prone communities are treated as recipients of professional socio-technical knowledge, Puzyreva and Basov (2000) found that there is a need to amplify and share local ecological knowledge to ensure that people's lived experiences, contextual knowledge, capacities, and needs are responded to, understood, and acknowledged.

Goldstein et al. (2015) offer one planning approach that uses personal narratives as key drivers in promoting social-ecological resilience in urban environments. Through storytelling, individuals are emboldened to subjectively share how environmental degradation has affected their urban systems and livelihoods and such storytelling may serve as the catalyst for initiating complex policy and community planning efforts to envision future alternatives (Goldstein et al. 2015). Sharing stories can also be a way to build cross-cultural understanding and shared competencies across differences, in order to strengthen more inclusive approaches to management and stewardship efforts (McMillen et al. 2020). Finally, risk communication plays

an important role in strengthening social ties and improving information sharing. Local, community-centered risk communication can address the varying perspectives and needs of affected individuals. Community-centered risk communication starts with engagement processes that lead to customized information products, and ultimately this two-way process of knowledge exchange can generate social and political will for preparedness action (Bier 2001; Martens et al. 2009; Terpstra et al. 2009; IPCC 2012; Shafer et al. 2016). In this context, our pilot study aims to use a co-production approach and qualitative methods to document and share lived experiences with chronic flooding to better understand social-emotional impacts and personal adaptations in order to inform more responsive, locally sensitive climate adaptation planning and communication approaches.

METHODS

Project background and study area

Increasing risk of flooding is especially concerning for coastal communities in New York City, which is surrounded by 520 miles of coastline and has approximately 400,000 residents situated either along the coast or in the 1% annual chance flood plain[1], based on FEMA's 2015 Preliminary Flood Insurance Rate Maps and the FEMA 2007 Flood Insurance Rate Maps (NYC DCP 2020a). The New York City Panel on Climate Change (NPCC) modeled a new dataset to project risk from high tides and Sea Level Rise, Mean Monthly High Water (MMHW), and mapped the areas subject to chronic flooding through 2100 (Orton et al. 2019). The NYC Community Flood Watch coordinated by NY Sea Grant and the Science and Resilience Institute at Jamaica Bay uses civic science contributions to collect photographs and data of tidal flood events, including date, time, depth, duration, and flooding source. Using photographs and reports collected by trained community members can help researchers and City officials build a novel dataset to track current conditions and validate the novel MMHW model developed by the NPCC. NYC Community Flood Watch operates primarily in the densely populated neighborhoods that border Jamaica Bay, a coastal estuary covering about 25,000 acres on the southeast side of New York City. Jamaica Bay experiences semidiurnal tides, as it is connected to the Atlantic Ocean via a narrow inlet. The surrounding neighborhoods are therefore vulnerable to the impacts of sea level rise and tidal fluctuations, and several neighborhoods already experience monthly coastal flooding.

This pilot study was co-produced by the NYC Community Flood Watch team: practitioners at a boundary organization, Science and Resilience Institute at Jamaica Bay, social scientists at the USDA Forest Service and decision-makers at a city agency, NYC Mayor's Office of Resiliency. Together we identified the dearth of qualitative data on social-emotional impacts of chronic flooding as a key knowledge gap not only in the scientific literature, but also for informing program implementation and expansion, as well as tailoring city adaptation responses. We jointly developed a study plan that laid out the aims and scope, research questions, methods, roles and responsibilities, with a commitment to shared decision-making and authorship as part of our approach. Specific set of outputs desired by agency decision-makers

[1] The 1% annual chance floodplain is the boundary of the flood that has a 1% chance of being equalled or exceeded in any given year. Also known as the 100-year floodplain (https://floodmaps.fema.gov/tutorials/check-ras/0.3_glossary.shtml)

included a “roster of social impacts” and a “roster of personal adaptations” as well as geographically explicit observations and experiences with chronic flooding in the form of maps in order to efficiently communicate observations, impacts, and adaptations in climate adaptation planning contexts. Finally, by having government agency representatives embedded in the research team, they ensured that research questions, methods, preliminary findings, and final results were shared iteratively with other city agency representatives to ensure that the scope and focus of the work would be useful and applicable in the end.

Our study area was comprised of the two communities currently involved in NYC Community Flood Watch at the time of the study: Hamilton Beach/Howard Beach (~40.6536°N, 73.8297°W) and the Eastern side of the Rockaways (including Rockaway Beach, Arverne, Edgemere, and Bayswater; ~40.5918°N, 73.79047°W), Queens, New York abutting Jamaica Bay. These coastal communities were selected by NYC Community Flood Watch because they are currently vulnerable to persistent, chronic flooding events (see Figures 1 and 2). The Rockaway community (defined here as Queens community district 14) is generally Black (35.8%) and White (34.2%), followed by Hispanic (23.9%). The percentage of the population that is 65 and over is 14.1%. In this community, there are 16,425 persons per square mile (NYC DCP 2020b). The population that lives in the 1% annual chance flood (based on FEMA’s 2015 Preliminary Flood Insurance Rate Maps (PFIRM) and the FEMA 2007 Flood Insurance Rate Maps (FIRM)) is approximately 75,0000, through a smaller subset of that population are currently experiencing chronic flooding. The Hamilton Beach/Howard Beach community (defined here as Queens community district 10) is generally Hispanic (25.8%) followed by Asian (23.7%) and White (21.5%). The percentage of the population that is 65 and over is 14.1%. In this community, there are 20,065 persons per square mile (NYC DCP 2020c). The population that lives in the 1% annual chance flood is 11,900 people, again with a smaller subset of that group experiencing chronic flooding events. The participants in NYC Community Flood Watch either reside or work in these New York City coastal communities and participation in the program is open to all.

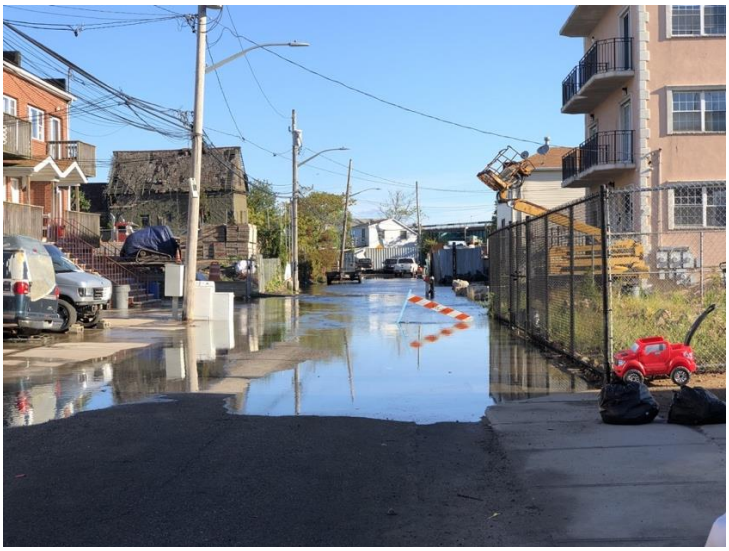

Figure 1: Flooding at Beach 84th Street in Rockaway Queens, NY 11693 Photo credit: NYC Community Flood Watch Project

Figure 2: Flooding at First Street in Hamilton Beach, Queens NY 11414 Photo credit: NYC Community Flood Watch Project

Recruitment

Interview participants were recruited through existing partnering community groups via the NYC Community Flood Watch. These partnering community groups came about from previous networks and collaborations developed by NY Sea Grant and the Science and Resilience Institute at Jamaica Bay based in the Jamaica Bay watershed. The extension specialists worked with these groups on bringing relevant programming and forums on flooding, preparedness, and other climate and weather-related information to their respective communities. Additionally, networks were also developed through introductions from local government partners such as New York City Emergency Management. These forums elicited perspectives and accounts of flooding from community members and called for further investigation and observations of flooding in these communities. Anecdotes of flooding impacts and reports of flooding were abundant from both Hamilton Beach/Howard Beach and the Rockaways.

Because NYC Community Flood Watch relies on the partnership of community groups that have a stronghold in their respective communities (and not necessarily single individuals), interviewees were recruited from the membership of aforementioned community groups through the help of leaders of those groups. A recruitment announcement was sent via e-mails to leaders of community partners and to project participants in direct contact with the extension specialist (n=12). Then either those leaders posted the announcement on their community group messaging boards, social media, or announced the opportunity at in-person community meetings led by partnering groups; this led to interested individuals to contact us via e-mail. Additionally, we were referred to community members who had local ecological knowledge and experiences of flooding. This led to seven referrals who were not participants reporting for NYC Community Flood Watch. From this pool of 19 recruits, there were nine interviews conducted, seven

nonresponses, three unable to find a suitable scheduling time, and zero refusals. As a recruitment incentive, all participants were eligible to enter a raffle for a solar lantern following their interview.

Data collection and analysis

All interviews were confidential, voluntary, conducted in person and lasted 1-1.5 hours in total (Cornell IRB #1910009143). Following the receipt of informed, oral consent, interviews were semi-structured in nature and interviewees (n=9) were asked a series of questions about their neighborhood background, flooding in their community, participation in NYC Community Flood Watch, and future visions. Participants were asked to describe locations within their community where they had personally observed flooding events since living or working there. These observations were collected in multiple forms - as street addresses, intersections, roadways and landmarks and locations were hand drawn on print maps as points, lines, polygons (see Figure 3). All locations were later digitized and stored in Google Maps. Upon completing the interview, participants submitted a demographic questionnaire. See Appendix 1for interview protocol and Appendix 2 for demographic questionnaire. Interviews were conducted by two members of the research team and followed by a paired debrief to discuss key themes, patterns, and incongruities in the data. Full team debriefs (LC, ES, HC, DK, PW) were also conducted at the completion of the interviews. All interviews were audio recorded, transcribed, and coded for emergent themes using NVivo11. The content was coded separately by two different researchers via an open coding scheme that identified key phrases and concepts (Lofland et al. 2005). These initial codes were compared and discussed iteratively until consensus was reached among the coders, thereby enhancing reliability (Neuman 2003). Specifically, for the roster of impacts and adaptations, all current and potential impacts named by respondents were identified and listed following an emergent coding process. These rosters were reviewed for completeness and compared against the original transcripts by two members of the research team. These themes and associated quotations are presented in the results below. When participant quotations are shared, parenthetical citations indicate the neighborhood and respondent number (e.g. Hamilton Beach is HB1 or Rockaway 2 is R2).

Figure 3: Example of hand-drawn map of flooding observations from a Rockaway participant.

Participant demographics

While the sample size of interviews is too small to conduct statistical analyses, we collected background demographic data to understand the composition of our interview respondent pool. We did not interview youth under age 18, but participants ranged in age from 29 to 64. The racial and ethnic composition of interviewees was: White (6), Black (2), and Hispanic (1). Long-term residents had lived in their neighborhood since the 1960s, but several more recent arrivals had done so over the last decade. Participants came from across a wide range of socio-economic statuses, including educational level (high school to graduate degree), income levels ($0 to over $120,000), home ownership and renters and employment status (students, fully employed, retirees).

RESULTS

Flooding Observations and Local Ecological Knowledge

We mapped participants' observations of flooding in their communities, overlaying all individual respondents to create two aggregate neighborhood maps (See Figures 4 and 5). Participants clearly identified 'hot spots' of flooding - both directly along shorelines, but also at inland locations. In both neighborhoods, participants recalled observing frequent flooding on residential and commercial streets. Participants also cited observing flooding near or at commuter subway stations. They took note of roadways that persistently flood, areas where they move their car to avoid damage, and locations where they had experienced particularly high water that made them change their route or even surrounded their vehicles. One respondent shared a particularly frightening and vivid incident of sunny day flooding on a local roadway that obscured the road

and surrounded her vehicle, using the local place name "Snake Road" for the flood-prone Brookville Road:

> "I've driven through Snake Road and the water came up to my window in my [Honda] Civic and I was just like, 'I'm already in this and I can't go backwards because there's a line of traffic backwards so -- God it's me and you today, get me through this!' And I don't know if I hadn't been familiar with the road if I would have been able to drive..." R1)

In addition to this particularly salient experience, the respondent described the way in which she has since changed her travel pattern and advises others to do so as well, to avoid this route:

> "Yeah, that was terrifying to me. I was just like, wow! So, I don't never go that way, not really… It's like, if it's high tide today, I can't go that way... [A family member] lives right on the end of Brookville down there, a completely direct route from his house to there but he has to think about it when he has my son and has to take him to school... I'm like did you check the tide today? And he's like 'why am I checking the tide?' I'm like 'because you may not be able to drive through Brookville. Sometimes Brookville is blocked up…. People who normally are accustomed to turning to go through Snake Road to get into Rosedale can't because the police or the fire department have blocked the road and no one's allowed to pass through, so then it creates more traffic..." (R1)

Figure 4: Howard Beach/Hamilton Beach chronic flooding observations. Data source: base map from Google Maps, overlaid with hand drawn flooding observations digitized from interviews. Map created by Helen Cheng. Observations recorded as points, lines, or polygons depending on how participants identified the location on the map.

Figure 5: Rockaway chronic flooding observations. Data source: base map from Google Maps, overlaid with hand drawn flooding observations digitized from interviews. Map created by Helen Cheng. Observations recorded as points, lines, or polygons depending on how participants identified the location on the map.

NYC Community Flood Watch participants have a finely honed local ecological knowledge that includes deep knowledge of exactly which streets and parcels are particularly flood prone. Long-term residents of these coastal communities described Hurricane Sandy as the "wake-up call" for the general public on the realities of living with sea level rise and flooding — a reality that they had been experiencing over several decades. Respondents reflected on chronic flooding as an everyday experience:

> "It's an everyday thing. It's just become that when the tide is high, especially if it's higher than normal: expect flooding, dress accordingly, park accordingly, determine if I care if these shoes get wet, do I care if these clothes get wet? ... It's always a surprising moment, like wait a minute, it didn't rain today, why is all this water here?" (R2)

> "Now it seems to happen like you know so much more frequently that the water will just be coming up, coming up, coming up and you wait and you're watching, it's high tide, it's rising, it's rising, it's rising. You don't know how far it's going to come up the stoop. You've got to run and if you're home, lucky enough to be home and you have another

> vehicle, you have to move a car. You have to see people race around in the morning, running around like crazy to move their cars." (HB2)

Other more recent residents of Hamilton Beach/Howard Beach described their experience of becoming more attuned to daily and seasonal rhythms of tides through personal observation and experience, reading tide charts, talking with peers, and participating in the NYC Community Flood Watch program. One respondent said, "I never knew that living by the water, we would have so many issues. I had to learn that the water's my neighbor. It's a very messy neighbor and it has its own rhythm…. started to notice like every time that it is a full moon or a new moon, there's water on 116th and 102nd Street" (HB3). Some participants have taken it upon themselves to notify their friends and neighbors when a high tide is coming and the need to move cars or ready basements, acting as a knowledge translator in interpreting complex forecasts.

> "I've always said it: you live by the water, so we can prepare for a hurricane, we can prepare for a nor'easter. But, all of a sudden, it's that sunny day flooding where, you know, somebody who's unaware – I stay up on it, I have a Facebook page, I post the tide charts on the Facebook page, and I give as much detailed information as I can, but I simplify it down so that people can understand it. Once you start reading through NOAA's forecast discussion, you know, many times I had to go to that glossary to find out what something meant…I make it so that a sixth grader can understand it, because then everybody can understand it." (HB1)

We find that local ecological knowledge is being built through direct, lived, experience and is being cultivated and shared through familial and peer networks. The role of having locally embedded, trusted information sources who can translate and relay technical forecasts into descriptions of the way which they will likely be experienced on the ground is crucial to adapting to living with water in communities surrounding Jamaica Bay.

Flooding Impacts and Adaptations

One of the aims of this pilot study was to create a *"roster of social impacts"* from tidal flooding in order to identify, describe, and contextualize these impacts to inform adaptation planning. Presented here in rank order of number of references are the impacts mentioned by our respondents (Table 1). Frequency of mentions is included to give a sense of relative commonness but should not be interpreted quantitatively due to the pilot nature of the study. Overall, impacts spanned several categories, including emotional distress, property damage, infrastructure damage, and time lost.

Table 1: Roster of social impacts of flooding mentioned by respondents

Impacts	Total mentions	Unique mentions
Emotional distress, frustration	15	4
Miss or late for work, school, appointment	14	7
Property damage	9	6
Flood insurance costs and challenges	6	4
Change travel routes or times	5	5
Dirt, debris, or contaminants in street to clean	4	4
Vegetation loss	3	3
Car stuck in flooding	2	2
Infrastructure damage	2	2
Lost tenants	2	1
Abandoned vehicles	1	1
Cancel events	1	1
Temporarily had to move	1	1

Many interview participants reported feeling distress or frustration when describing tidal flooding events. Emotions expressed included anxiety, fear, nervousness, and frustration over challenges in mobility, damages to property, and potential danger to self, family, and neighbors. In addition to these emotional effects, other social and economic impacts included being late to or missing work, school, appointments and sustaining property damages to home and cars. Sunny day tidal flooding was more often described as a chronic nuisance or hardship that residents had to adapt to on a regular basis, in contrast to more extreme events such as nor'easters and hurricanes that caused more lasting damages to property and impacts to livelihoods. While no one singular event has the impact of Hurricane Sandy in NYC, the accumulated total of these disruptions and important missed events has taken an emotional toll, as illustrated by these quotations:

> "We were supposed to have Christmas here one year at the old house. And all of a sudden, Christmas Eve, we get a high tide. It's a freak high tide. Nobody called it, nobody

> said anything, and I had just finished replacing the rug for the kids to come over to play downstairs, and the tide came in and hit the rug. So, you know, it's disappointing at that point. So, we had to cancel that day and we had to go to my sister-in-law's house for Christmas instead of coming here. So, you know, it bums you out. My wife was bummed out. She had started cooking three days before [Christmas]." (HB1)

> "I just, I don't see it the same way anymore because of the constant flooding. I don't feel like a secured safeness that I can stay here, I don't feel it anymore. I just don't like that hanging over my head all the time. You know, life's tough enough without having something that is just like you're waiting for like a bomb to go off. When's the next one coming, you know?" (HB2)

It was noted that the impacts of everyday or extreme flooding are not evenly experienced across communities, and that vulnerable populations such as seniors living alone or people with underlying health conditions are more at risk when travel is inhibited. Specific concerns were voiced for people with chronic health issues or disabilities who rely on assistive devices that require electricity or who require access to medication sent through the mail, both of which can be disrupted by flood events. Overall, concerns about mobility were frequently identified.

> "There's a school bus stop right out front and on days when there's a high tide, the kids are getting off the bus into a pool of water. I've seen it, I have pictures actually of the kids walking across a plank to get into the school bus that we put up there, because how else are they going to get onto the bus without wading through the deep water?" (R1)

> "We have a few residents in these buildings especially who are in either motorized or pushed wheelchairs and when the tide is really high, this intersection right here where our side lot is, it used to be a road that's a longer road but when the tide comes up at 58th Street, that storm grate right there -- they cannot get across the street. So if someone has to go to the train station, they would have to go all the way down...and take a chance and go under the freeway which is, which has no sidewalk. There's not a walking path. It's actually pretty dangerous to be walking under there. But that's usually where everyone walks simply because it's dry and less likely to be flooded." (R2)

We also created a *"roster of personal adaptations"* that residents took on in response to tidal flooding, which spanned a few main categorical types, including transportation/mobility; housing modifications; relocation; and use of personal gear (see Table 2). These personal adaptations range in degree of intensity from changing behaviors, to making different consumer choices, to longer term investments and planning around housing choice. As above, frequency of mentions is included to give a sense of rank order but should not be interpreted quantitatively due to the pilot nature of the study.

Table 2: Roster of personal adaptations to flood events mentioned by respondents

Adaptations	Total mentions	Unique mentions
Change travel routes or times, cancel travel	20	7
Move car	11	5
Leave, sell, buyout homes	8	4
Sump pump, water pump	8	4
Carry boots	7	3
Buy specific type of car	5	2
Move items out of basement	3	2
Create and modify berms or walls	2	2
Live on houseboat	2	1
Would not buy home in area	2	2
Block street with tape	1	1
Building retrofits or reinforcements	1	1
Canoe in streets	1	1
Carry “go bag” in car	1	1
Change dress attire	1	1
Change event timing	1	1
Local fire department send emergency notifications	1	1

For example, participants reported using measures such as consistently checking tidal charts, regularly moving cars, leaving early or staying out later to avoid flooded streets, keeping waterproof boots in their vehicles, and avoiding travel down streets that are prone to flooding. Other more resource-intensive adaptations included purchasing higher clearance vehicles, retrofitting homes, and building makeshift berms. At the community level, in Hamilton Beach, participants reported that the local Volunteer Fire Department has repurposed the use of their

alarm system to signal high tides as a neighborhood warning system. A few illustrative quotations are shared below.

> "Some people don't have the luxury of calling in late, you know. I know people down here who - one guy's a bus driver - so what does he have to do? High tide's at 7. He goes, "I'm leaving the house at 5", and he goes somewhere and sits in his car for two hours until he has to be at work." (HB1)

> "One of the biggest issues, I think, is you have to check the tide table before you park your car even if you're parking today, it could be dry tonight and tomorrow morning you come outside and it's like ahh man, I need waders to get to my car…" (R1)

While the focus of this study was not on larger-scale adaptations, such as coastal retreat, we wanted to understand how future possibilities and longer time horizons were understood and perceived by residents. When asked where they saw themselves in ten years, the majority of respondents claimed they had no intention of leaving their communities in the future, despite the potential for worsening flood events. At the same time, others identified that given current conditions, they would make different locational choices than they had in the past, and one renter affirmed that "I will probably never buy a house in Rockaway" (R4). Some respondents actively discouraged others not to move to the neighborhood, or not to plan on passing on homes to future generations. Others reflected on the existing level of flood risk exposure in their neighborhoods, the crisis of affordability citywide, and the continued development pressure in their communities. Some illustrative quotations:

> "The only thing I say is if someone is looking to buy a house here and then have children in which to pass the house on to so that the kids can either live in it or sell it, you might want to think twice about that." (R6)

> "Often I think whether or not I want to relocate… There's a big possibility that I might relocate but I'm not 100% sure today…. I know a lot of people are moving out here because the housing is more reasonable than in say Brooklyn but I don't think they're aware and I think it's a real culture shock to them when they get out here and they're like 'oh I need waders?" (R2)

> "I think that people are going to start moving further and further east in Rockaway. It's already happening, [people] coming from other places 'cause people want to live on the beach and it's cheaper than other places in New York. And there's a huge community of people that are already out there that can't afford to live anywhere else, and so they're stuck in this place that has all these environmental justice issues and then now we're going to compound that by putting up new developments and encouraging more people to come live there too, so it's kind of crazy." (R4)

Finally, at a structural or systemic level, some interviewees reflected on the limited residential mobility choice of low-income residents and public housing residents who have less options to relocate if they wanted to move to a less flood prone area. Better understanding how residents

conceptualize futures for themselves, their households, and their communities can help inform long-term planning.

Community Connectedness, Sense of Place, and Civic Engagement

Most interview participants reported sentiments of community connectedness, rooted in community pride and sense of place. Sense of place is a multi-dimensional concept about people-place relations composed of place attachment, place beliefs, and place dependence (see, e.g. Jorgensen and Stedman 2006). Respondents maintained long-standing generational ties to their communities that fostered deep place attachments and continued to have extended family living nearby. One respondent described the feeling of safety and connectedness that comes from living in such a tight-knit community with close social networks but noted that flooding is eroding that sense of safety. Others affirmed that despite all challenges, they would remain in place. Some illustrative quotations of these themes are below.

> "I think one of the strengths that we have in Hamilton Beach is it's like a small town. Everybody knows everybody. Everybody knows what's going on. That's good and bad. But everyone knows everybody, and we all watch out for each other. I can tell you the truth. Prior to Sandy... I never locked my front door. It was that type of community…. I was raised here. I'm raising my kids here, you know." (HB1)

> "I'm here for a long time and my neighbors, most of my neighbors on this block are here a long time so we know each other. I know the kids I saw since they were babies - they're in their 20's. That is a nice support, you come home [and feel] safe, in that regard. But the water's really pushing it the other way." (HB2)

> "I'm not moving. Now I sound like my mother and my grandmother, my grandmother said 'I'm going to die in this house,' she did, 99 years old and my mother stayed in her house which was on my block also, my grandmother lived around the corner and she ended up in the hospital and died in the hospital. She said 'I'm never leaving' and I even if when I get older, I don't know how old I'm going to live, but um I may go away for a month...but I would always come back here, 'cause this is my home." (R3)

> "Listen, I don't plan on going anywhere. I'm 57-years-old, I'm not going to retire for at least another ten years. But listen, I'm going to do the civic [association] as long as I can do the civic [association]...Everybody tells me - elected officials will say it - you know, you've done so much for this community. You get things done. And I say it all the time: you gotta' take care of home and this is home." (HB1)

Building upon this sense of community connectedness, many NYC Community Flood Watch participants are civically engaged as members or even leaders of local civic and environmental organizations and community boards, serving as trusted local "brokers" and information providers in their neighborhoods (see also Svendsen and Campbell 2008). They have been heavily involved in awareness-raising and advocacy work around coastal resiliency, infrastructure improvements, and neighborhood quality of life. Advocacy work has taken many forms, including holding rallies, participating in government meetings, building relationships

directly with elected officials at multiple scales of government, writing pieces in local media or talking to local newscasters, and using social media. In addition to advocacy work, environmental education programs were one key way that residents were involved in shaping the knowledge and skills of future generations of residents. Respondents were often affiliated with a neighborhood civic organization or a local environmental justice organization. One Rockaway respondent identified that the diversity of their community was its greatest strength, particularly its ability to come together via a civic organization. Despite the heavy civic engagement of many interviewees, respondents also acknowledged the limits of what this sort of local organizing can do - given everyone's finite time and resources. The two following quotations illustrate both the importance and limitations of civic capacity:

> "In my experience, the strengths of that community were its diversity in culture, race, and age. I was mostly dealing with the youth in programs, but we had the whole volunteer program that were older people and retired people. Our farm share brought in a huge amount of people, everyone from the hip restaurant owners to older folks in the community, so I think the strengths of the community are for sure its diversity and specifically in the space of [local community organization], everyone's ability to come together and understand the issues of the community. I don't know if that's representative of all of Rockaway or just this really unique sliver that I was seeing." (R4)

> "Everybody's busy, everybody's working full time. Yeah, who's got kids, who's running here, who's working two jobs…. People that work all day and you come home, you cook dinner, you do this and the next day you're going to work again… In the winter you're kind of in with the cold, in the summer everybody's doing their things. I think we kind of realize there's not much we could do. We could put sump pumps in, the French drains and watch and move your car, what else could you do?" (HB2)

We found that thick social networks—defined as numerous, highly connected social ties--and high degrees of civic engagement were both important building blocks for fostering social resilience to chronic flooding. In addition to these strong local ties, bridging and linking ties to other communities, sectors, and scales of decision-making are key.

Local peer networks that are facilitated both in person and online are important ways that trusted information about flooding circulates. Also noted as key information sources about flooding were local newspapers and news channels, surf reports, and tide reports. One local community Facebook page in Hamilton Beach was founded with the express goal of sharing flood information, observations, and photos. Respondents also discussed the importance of neighborhood listservs and group email threads. However, respondents were reflective that not everyone uses online tools -- particularly older residents -- and that there remains a need for calling, texting, door knocking, and checking in on neighbors physically. One respondent was reflective about pre-existing divisions and differences in the community--such as racial and economic divides as well as linguistic and cultural barriers, which affect the way that information flows:

> "There is still this really big separation of like information and what to do with information and how to help each other especially if we're in a situation like with Sandy

> where Staten Island had a community that like got together with the city and like figured out how to be relocated after all that and bought out but with the Rockaways, because the community is so vast and like racially divided or seemingly so, there's so little overlap with communication between like literally Black and White so I don't know how we're supposed to take care of each other if we have that divide… It's more about us communicating with each other and bonding in that way in order to help one another before we have to rely on the city to deal with it at the end of the day." (R5)

Another respondent noted that a substantial Orthodox Jewish population resides in Rockaway, some of whom do not speak English or speak English as a second language and who do not use technology each week during Shabbat, which can lead to particular vulnerabilities if flood events occur during these times. Interviewees saw the need to bridge these divisions and build trust as key to fostering more effective planning, response, and adaptation to disturbances.

Finally, in addition to better understanding community sense of place and civic engagement - we sought to understand residents' relationship to government around issues of flooding and coastal adaptation planning. A frequently mentioned mode of interaction was through the city's 311 service request line -- but there was a recognition that this communication channel is necessary, but not sufficient. Participants reflected on the importance of programs like NYC Community Flood Watch for providing a trusted source of information about flooding impacts -- particularly when interacting with government officials.

> "We also try to call 311 and encourage everyone else, call 311 to report flooding and I know growing up in a less affluent neighborhood, people don't usually call 311 and it's probably a thing because like my mom told me 'why you calling 311 to complain' and I had to tell her 'I'm not calling to complain, it's for reporting purposes' because when I call 311 and I tell them there's flooding, when the city agency is making their reports at the end of the year, that is how they determine if there's actually flooding. If no one is reporting this, then how can you know? They'll think, oh there's no floods there because if they're not driving through here on a regular basis, how would you possibly know? And I think a big thing would be encouraging the residents who deal with it on their street on a daily basis to make those reports. You're not being a pest; you're probably doing yourself a disservice by not making those reports…" (R2)

> "I love this project 'cause if it gets us help, especially, maybe to raise this road. The road is below sea level so when the tide is high, it's a disaster. [The city] raised the sewer main saying it would work. For instance, the water main broke this morning and DEP [NYC Department of Environmental Protection] is out there, he's like 'this road doesn't flood'. I was like 'I don't know where you got your information from, sir, but this road floods all the time'. He's like 'not since they raised the thing'. I was just like 'I can show you pictures from flooding last week where this whole road was a lake'. I mean it wasn't as deep as it is today but it was, the picture was what, 5" of water?" (R2)

The overwhelming sentiment expressed was a desire for the government to more proactively provide local flood protection across a whole range of approaches, from grey infrastructure, to nature-based features, to property buyouts. While some interviewees shared

success stories of advocacy that led to measures such as road elevation or installation of sewer check valves, others lamented that the government does not adequately respond to the distinct needs of their communities, including addressing persistent flood-prone streets — particularly access points that can inhibit vehicular traffic flow into and out of neighborhoods. Respondents questioned the pace of change in developing flood mitigation and adaptation measures, causing a sense of frustration or even distrust over lack of progress on measures. This has been noted particularly since Hurricane Sandy with the number of large-scale studies, plans, and proposals being led by what one respondent called "alphabet agencies" -- including Federal Emergency Management Agency (FEMA) and the US Army Corps of Engineers. Others pointed to the need for more interagency and cross-jurisdictional coordination -- particularly as the Rockaway peninsula spans several NYC neighborhoods and abuts Long Island communities:

> "I had to tell all our community leaders that this meeting was going to be in Freeport [Long Island], they knew nothing about it. I said, 'but if I'm getting the email, why aren't the important people getting the email?' I was the only one that showed up. No one from any of the Rockaways came…. We're one peninsula, [but] we're split in half. This part of the peninsula is with Rosedale and Jamaica which makes no sense; this part is with Broad Channel going towards Howard Beach which is different also. I think we need to be united.... It's the district, like our assemblymen are different, our councilman is different and our senator…. Everyone says it's a divided Rockaways and it really is, but I think the politicians have made it that way also." (R3)

Although not the core focus of this study, we found that interviewees were generally highly knowledgeable about existing flood insurance resources and flood mitigation mechanisms—they reported knowing where to go to get information, understanding their insurance eligibility status, and knowing what options were available to retrofit their homes. In these reflections about relationships to government, it is challenging to disentangle the desire for protection from extreme weather and what measures might be taken to address more chronic, everyday flooding. Overall, NYC Community Flood Watch participants are actively engaged in both reporting flooding, working within the civic arena to raise awareness and advocate, and connecting with government to have their voices heard. Our findings suggest a need to continue to foster open, trusting relationships across sectors and the multiple scales of government.

DISCUSSION

NYC Community Flood Watch represents a first step in the creation of a baseline dataset to track current conditions of tidal flooding and--with this pilot study--its social-emotional impacts in some of New York City's lowest-lying neighborhoods. Civic scientists are often asked to gather data about their biophysical environments; in this case, research participants were also given an opportunity to share their experiences and social world – to give context to and share stories about these observations of flooding. We found that NYC Community Flood Watch participants who engaged in this research are knowledgeable about and engaged with the processes, rhythms, and impacts of tidal flooding. Qualitative methods can be used to document flooding impacts, identify sources of adaptive capacity, and inform planning processes. The social impacts of living with semi-regular tidal flooding are important considerations for policies or programs designed to mitigate flooding and/or flooding impacts, at municipal, state, and federal levels and

across infrastructure, emergency, and planning sectors. This work demonstrates the need to attune our methods and data collection to better capture and understand lived experience, local ecological knowledge, and civic engagement--as these are crucial building blocks for strengthening social resilience (see, e.g. McMillen et al. 2016). Finally, by rooting the research in civic science and a co-production approach, this study provides a starting point for more effective risk communication and building shared knowledge across different stakeholders to inform collaborative adaptation planning, as described below.

Interviews elicited details about the timing, sequence, intensity, and impacts of chronic flooding, reflecting the importance of gathering qualitative data about direct, lived experiences and drawing upon local ecological knowledge. In contrast to time-bound, highly visible extreme events, sunny day flooding occurs gradually over time, creating persistent, but nonetheless harmful effects. These effects include not only direct costs and lost time and inconvenience, but the emotional impacts associated with repeated disruption and unpredictability of flooding events. Sunny day high tide flooding is experienced unevenly, exacerbating pre-existing vulnerabilities, and reflecting variation in residents' perceptions of risk and ability to respond or adapt. Identifying localized adaptation measures from participant interviews provides important data and context related to chronic flooding impacts and risk communication and mitigation strategies for planners and decision-makers. By asking respondents to reflect on sources of information and means of information sharing – we identify potential alternative pathways for communicating information and risk about chronic flooding that is locally trusted and relevant. For example, peer-to-peer methods for tidal flood alert communication, such as community-wide text message services and communication channels via neighbors, can inform residents of impending flood events while bolstering social support for localized action. Since adaptations are hyper-local, we know localized communication on flood risk can assist residents in mitigating impacts. Surfacing, sharing, and amplifying lived experience and local ecological knowledge in a climate adaptation planning context can better ensure that risk messages, communication methods, and solutions are tailored to meet residents most direct and pressing needs and targeted to the particular cultural context.

This study represents an integrated approach to produce novel data that communities grappling with climate-induced flooding can use to enhance and expand the effectiveness of adaptation planning and implementation through providing local governments with detailed information on the social-emotional impacts of sunny-day flooding from tides and sea level rise. These findings can be used to improve related resilience extension, communication, and outreach tools. The results of this research will assist communities by documenting impacts of climate-induced flooding on residents' lives and sharing these experiences with decision-makers, planners, and other practitioners. Oftentimes, governments and agencies have access to limited resources for climate adaptation investment. Those with decision-making power may need these kinds of local data about lived experiences to have a complete understanding of the multiple impacts of flooding on communities as well as the variety of adaptations made to mitigate impacts. Our co-production approach engaged researchers, government decision-makers, and a boundary organization in this project as we worked to surface and amplify the lived experiences of residents. Through engaging government decision-makers as research partners in the project development and implementation, agency concerns were incorporated into collection instruments, and trust in resulting data was enhanced. NYC Community Flood Watch

participants act as 'civic sensors' -- sharing information about the timing, duration, and physical impacts of flooding events. By capturing the stories, experiences, and emotions of these knowledgeable residents in frontline communities, we gain a better understanding of the social-emotional impacts of these events--as well as sources of social support, modes of civic engagement, and locally driven adaptation measures. Without a methodology and a trusted research and engagement process, these stories would remain at worst unheard or at best, considered as 'anecdotal', whereas in this context they are valued as data. Across our project team that included federal scientists, municipal decision-makers, and practitioners in boundary organizations, we built a shared understanding of each other's' questions, programs, and policy concerns. By working together to gather and analyze qualitative data about impacts of and adaptations to chronic flooding, we better sensitized our efforts to the experience and needs of community residents whom we are aiming to understand and serve.

As a pilot study, we acknowledge that this research has several limitations. The small sample size of included participants does not capture the full range of lived experiences with flooding. By recruiting from among a pool of engaged civic scientists, we cannot generalize to the experience of non-participants who may have very different perceptions, knowledge, and experiences with chronic flooding. Indeed, with additional recruitment both within the target neighborhoods of the study area and across broader coastal geographies, the list and rank order of the roster of impacts and adaptations would likely shift. However, we believe that our co-production approach, our interview protocol, and our analyses can translate to other locations and contexts.

Going forward, future research-action efforts should aim to build upon this trusted, collaboratively generated data and relationships to build new knowledge across disciplines and to answer the call for meaningful engagement of residents in community resilience planning (see, e.g. Ramasubramanian et al. 2016). For example, continuing to convene these diverse stakeholders with a focus on shared learning, effective risk communication strategies, collaborative planning, and solutions-generation, such as through the form of sustained "competency groups", would deepen and extend this work (see, e.g Landström et al. 2011; Whatmore and Landström 2011). Future research should also further examine different populations in flood-prone communities, including but not limited to: business owners, renters, public housing residents, youth, seniors, and schools to better understand the full breadth and diversity of flooding impacts in New York City. Particular attention should be paid to the ways in which vulnerable populations are impacted by chronic flooding and how they can be better supported through planning and adaptation measures.

APPENDICES

Appendix 1: Interview Protocol

Neighborhood background

1. To get us started, can you tell us where you live, how long you have been living at your current residence, and how long you have lived in the neighborhood?
    a. Please describe your home – is it a house or apartment, do you rent, own, or some other arrangement?

2. What do you think are the strengths of your community? What do you like about living here? Are there specific things that influenced your decision to live here?

3. Are there challenges to living in this neighborhood? Please describe.

Flooding

Thanks for that background. Now we are going to talk about your experience with flooding in your community.

[Introduce the neighborhood map – if participant is not comfortable map-reading, be prepared to locate sites yourself as they narrate places]

4. Over the course of that time, what changes in flooding have you observed?

5. How is flooding impacting your day-to-day routines?
    a. Has flooding ever caused you to miss work or school? To be late for an appointment? Or to miss an event? Please describe.
    b. Has flooding caused any property damages? Please describe.
    c. Has flooding affect your experience of living in your neighborhood, such as visiting parks, walking down the street, socializing with your neighbors, running errands, or shopping at local businesses? Please describe.
    d. Have you changed your behavior due to flooding? For example, is there something you no longer do or a place you no longer visit due to flooding or changed your route to get to a location?
    e. Are there particular members of your community that you are most concerned about being vulnerable to or affected by these flooding events? Please describe.

6. How are you dealing with these disruptions? What do you do? Can you share some specific examples of ways that you have adapted to living with flooding?

7. Other than Hurricane Sandy, is there one particular story of a flooding event that impacted you that you could share with us?

8. What are you go-to sources of information about flooding in your community?

9. And who do you speak with to try and address concerns about flooding? (E.g. local groups, public officials)?
    a. Do you feel the city has listened to your community's concerns?
    b. Are you aware of or involved with any local groups that take action on flooding? If so, please name them. How did you learn about them?

10. Other than the sort of large-scale city, regional coastal protection measures that are often discussed in the media, are there any specific, local recommendations you have that could help mitigate or address some of the challenges you face?

Thanks for sharing those insights. We have a few more questions specifically about the [program name]:

11. How did you learn about [program name]? And what motivated you to participate in the program?

12. What has your experience been like participating in [program name]? Are you consistently reporting through [program name]h? Why or why not?

13. In your opinion, how can [program name] best recruit new participants in your community?

14. We are interviewing a sample of [program name] participants for this study. Who else should we speak to in your community about their experiences with flooding?

We have just one final, big picture question for you:

15. Where do you see yourself in 10 years?

Appendix 2: Demographics Questionnaire:

1. What is your age (as of your last birthday)? _____

2. Please specify your home ZIP code: _____

3. What year did you move to current residence? _____

4. What year did you move to your current neighborhood? _____

5. What is the highest level of education you have completed? (please choose one)
Some High School
High School
Some University
University
Graduate or Professional School

6. In what sector are you employed (please choose one):
Government or Public Sector
Private sector
NGO or non-profit
Self-employed
Student
Retired
Not employed
Other _____

7. What is your approximate annual household income? (please choose one)
$0-$4,999
$5,000-$9,999
$10,000-$14,999
$15,000-$19,999
$20,000-$29,999
$30,000-$39,999
$40,000-$49,999
$50,000-$69,999
$70,000-$89,999
$90,000-$119,999
$120,000 and over
Prefer not to answer

8. What is your race? (choose all that apply)
African-American / Black
Asian-American
Latino / Hispanic

Caucasian / White
Native-American
Other (please specify) _____

9. Do you speak any languages other than English at home? If so, please specify:

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