Coastal Flooding and Environmental Justice: Identifying Potential Strategies for Adapting to Climate Change in two urban communities in the Boston Metropolitan area, Massachusetts

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Abstract

We explored the possible future impacts of increased coastal flooding due to sea level rise and the potential adaptive responses of two urban, environmental justice communities in the metropolitan Boston area of Massachusetts: East Boston and Everett. East Boston is predominantly a residential area with some industrial and commercial activities, particularly along the coastal fringe. Forty-two percent of East Boston residents were foreign-born and approximately 20 percent of families live below the poverty level. Everett, a city to the north of Boston, has a diversified industrial and commercial base. The minority population of Everett is 25 percent and approximately one-third of foreign born residents are Hispanic. While these two communities have similar socioeconomic characteristics, they differ substantially in the extent to which residents would be impacted by increased coastal flooding. In East Boston, a large portion of residents would be flooded, while in Everett, it is the commercial/industrial districts that are primarily vulnerable. Through a series of workshops with residents in each community, we found that there exist a myriad of social and cultural obstacles to adaptation in these communities that limit their adaptive capacity. Our analysis indicates that the target populations in these communities do not have an adaptation perspective or knowledge of any resources that could assist them in this challenge. However, a common incentive for both communities was an eagerness to learn more and become actively engaged in decisions regarding climate change adaptation. Understanding existing cultural knowledge and values about adaptation to climate change must be part of the framework for adaptation planning.

1. Introduction

In the year 2000, about17 percent of the global population lived in the world's coastal zone (Argady et al, 2005). Furthermore, approximately 8 percent of urban area and 13.5 percent of the global urban population are estimated to reside in the coastal zone (McGranahan et al., 2006). Based upon a slightly more expansive definition of the coastal zone, the IPCC (2007, WG2) estimate that approximately 33 percent of global population will live in coastal and low lying areas by 2080. Over the last decade, the link between anthropogenic-climate change and its impacts on terrestrial and marine systems have become increasingly undeniable (IPCC, 2007, WG1). In February 2007, the Intergovernmental Panel on Climate Change Working Group 2 (IPCC, 2007, WG2) concluded that, "coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas."

In the US, over 50 percent of the US population now lives in the coastal zone and the number is projected to increase (Wilbanks et al., 2008). Most of these coastal dwellers are and will be in urban areas. Coastal communities are subject to both inland and ocean-related climate change impacts, such as rising temperatures, increased extreme and variable precipitation, and higher sea levels. The rising sea levels will likely cause more flooding of land during high tides and storm surges. Storm surges may also be increasing due to the observed increasing intensity of coastal storms (USGCRP, 2008). Many coastal dwellers are already vulnerable to coastal flooding; with sea level rise due to climate change, continued land subsidence, and probable increases in the intensity and frequency of coastal storms, their vulnerabilities will almost certainly increase over the

next few decades. There has been considerable research on the possible increases in coastal flooding, but very little research on the distribution of impacts by socio-economic categories. The focus of this research was on possible impacts on urban populations that are already suffering from environmental injustices (so called environmental justice or EJ communities) and hence are particularly vulnerable to the consequences of climate change because of their limited adaptation options. Adaptation to reduce a region's vulnerability to climate change can be accomplished by both reducing the actual climate change through mitigation and managing its exposure, sensitivity and adaptive capacity. Here we acknowledge the critical need for mitigation but also that adaptation to climate change must be undertaken because climate change cannot now be reversed by mitigation. Only the rate of change can be decreased; changes will continue for centuries (Solomon et al., 2009).

In this paper, we present the results of our evaluation of climate change impacts and adaptation options for two urbanized coastal communities, East Boston and Everett, in the Boston metropolitan area. These two communities are classified as environmental justice (EJ) communities (defined below) and were selected so that we could identify the obstacles and incentives for urban EJ communities in adapting to the consequences of sea level rise due to climate change. Results of a parallel study by the authors for two rural EJ communities along the eastern shore of the Chesapeake Bay in Maryland is presented in Paolisso et al. (2011).

1.1 What is Environmental Justice?

The concept of "environmental justice" arose from the now well-documented observation that low-income minority communities have historically borne a

disproportionate share of environmental hazards (Checker, 2005; Johnston, 2011). In urban areas, low-income populations and communities of color are exposed to a disproportionate number of harmful conditions. These include toxics in air and groundwater from past industrial practices and vehicle emissions; contaminated or abandoned industrial sites (brownfields); illegal dumping; vacant lots and abandoned buildings; lack or neglect of greenspace, failing infrastructure, relatively few economic opportunities, higher density housing; human health problems, higher overall mortality and infant mortality rates, poor access to health care, inadequate health education, fewer opportunities for safe recreation; poor quality housing, inequitable access to transit services; and community isolation or displacement.

Steps to manage a coastal area's exposure and sensitivity are not possible without the adaptive capacity to implement them. Here we examine the social and cultural incentives and obstacles to adaptation to increased coastal flooding due to sea level rise (SLR) and assess how the community's social and cultural characteristics complicate land use planning and other aspects of adaptation planning. Despite these obstacles there are also some incentives upon which to capitalize. Thus further insights are provided here on the challenges of adjustment or adaptation to climate change in an urban area. While the communities are subject to more climate change impacts than just SLR (Kirshen et al., 2008a), it is the only impact considered here. In both East Boston and Everett, due to the topography and the highly urbanized coast line, permanent loss of land and wetlands and increased erosion are not major factors, as is the case in some other regions of the US such as Chesapeake Bay and Florida. Thus only storm surge impacts are examined here.

1.2 Climate Change and Sea Level Rise

One of the impacts of the changing climate has been an increase in sea level because of the melting of ice on land and thermal expansion of the ocean as it is warmed (the sum of both is eustatic sea level rise, Pugh, 2004). The long term (1880-200) average rate of eustatic sea level rise (the combination of thermal expansion and ice melt) has been estimated to be on the order of 1.6 mm yr^{-1} (Bindoff and Willebrand 2007). Sea level elevation relative to land is also related to vertical land movement (uplift or subsidence) that is due to both geologic and human-induced effects which vary with location. Total or relative sea level rise (RSLR) describes both eustatic SLR and vertical land movement. In Boston in the northeastern United States, land subsidence is estimated to have been 1.1 mm yr^{-1} and RSLR has averaged 2.65 mm yr^{-1} over approximately the last 100 years (Kirshen et al. (2008b). The effects of SLR in the coastal zone generally include displacement and loss of wetlands, inundation of low-lying property, increased erosion of the shoreline, change in the extent of flood zones, changing water circulation patterns, and more salt water intrusion into groundwater. Eustatic sea level rise projections range from 0.8 m (most plausible) to 2 m (possible, but unlikely) by Pfeffer et al. (2008), 0.3 to 0.5 m (moderate temperature scenario) to 0.4 to 0.8 m (warm temperature scenario) by Katsman et al (2008) and 1.0 to 1.4 m by 2100, with the range of uncertainty spanning 0.8 to 1.9 m (Vermeer and Rahmstorf, 2009). Furthermore, Yin et al (2009) found that in response to a possible weakening of the Atlantic Meridional Overturning Circulation there could be an additional 0.16 to 0.24 m of regional dynamic sea-level rise by 2100 in Boston.

1.3 Environmental Justice and Climate Change

There is now a large and growing literature focused on understanding the relationships between cultural, socioeconomic, race and ethnicity, and environmental hazards. Much of the recent literature is related to exposure to pollution emissions (Downey, 2005; 2007; Diawara, 2006; Pastor et al., 2006; Krieg, 2005) and public health (Resnik and Roman, 2007; Lambert et al., 2006, Chess et al., 2005). Since Hurricane Katrina devastated the Gulf Coast in August 2005, a few studies have highlighted racial and economic injustices in response to natural disasters (Allen, 2007; Pezzolli et al., 2007; Elliot and Pais, 2006. Until very recently, little attention had been paid to challenges of EJ communities in the face of climate change, which by its very nature is a more insidious and expansive threat than that posed by present natural disasters. A report by the Congressional Black Caucus Foundation (CBCF, 2004) highlighted the disparity between those who benefit from and those who bear the burden of climate change and national climate change policies. More recent research has been published by Norgaard (2006), Page (2007), Soskolne et al., 2007 and Ruth and Ibarraran (2009). While not directly examining the impacts of climate change, Clark et al., (1998) found that physical vulnerability to flooding must be combined with the socio-economic vulnerabilities in coastal flood management in Revere, Massachusetts.

Environmental justice considerations will only increase as the impacts of climate change and sea level rise become more widely known and as policy and program efforts expand to build adaptive capacity. “Climate change reflects and increases social inequality in a series of ways, including who suffers most its consequences, who caused the problem, who is expected to act, and who has the resources to do so,” (Mohai et al.,

2009, pg. 420). The events surrounding Hurricane Katrina exemplified the disparities among people of different racial and socioeconomic groups and how they might be affected differently by incidences of extreme weather and climate change. It also demonstrated the need for special adaptive considerations for certain groups of people. Of particular concern regarding the Katrina disaster are who was living in neighborhoods that were vulnerable to flooding, which groups were evacuated during the flood, how different groups were treated during the evacuation, which neighborhoods belonging to which groups were rebuilt, and who is represented in the decision making process concerning these issues surrounding Katrina and other areas vulnerable to these types of disasters in the U.S. (Mohai et al., 2009).

1.4 Adaptation for SLR

While climate change and sea level rise are global problems, the consequences will be suffered locally, hence adaptation will need to be enacted at a local level. As such, individuals trying to adapt to climate change and the resulting extreme weather and sea level rise will be limited by their socioeconomic and institutional capacity (Adger 2001), which can be low in EJ communities. Cultural understanding of specific groups can facilitate adaptation of vulnerable groups by finding solutions that will reduce the impacts of climate change on those communities. The best way to enact adaptation to climate change impacts is to take a proactive response to prepare the natural and built environments for the impacts of climate change. However, compared to many other planning processes, the major challenge of adaptation planning is the consideration of uncertainties of future climates and other drivers such as population growth, land use change, and technological innovation. At its best, adaptation planning is itself a dynamic

and adaptive process given the uncertainties associated with climate and other changes. Most experts (IPCC, 2001; Natural Resources Canada, 2002; USCCSP, 2009) agree with the IPCC (1990) formulation that adaptation responses to SLR for urban areas include protection, accommodation, and retreat. Protection attempts to manage the hazard with "hard" structures such as seawalls and groins or “soft” measures such as beach nourishment and wetland restoration. Accommodation allows human activities and the hazard to coexist through actions such as flood proofing of homes and businesses and evacuation planning. Retreat removes human activity from the vulnerable area which generally is accomplished by abandoning land as the sea rises. Each of these strategies has different economic, social, and environmental impacts and policy implications that are highly site dependent. Thus it is particularly important to have a social and cultural understanding of these limitations in order to facilitate adaptation of these vulnerable groups. Of course, there is also always the option of taking no action, but much research (e.g., Kirshen et al., 2008a; National Research Council, 2010) shows that this is generally the least effective (and most costly over the long term) response in developed areas. As discussed subsequently in this paper, the extent of areas vulnerable to flooding could be significantly larger in the future due to due to climate change; it is this threat and the potential human consequences, especially in communities with little capacity to adapt, that served as the motivation for this study.

2. Research Methods and Analysis

2.1 Study areas

For this research, we selected East Boston and Everett, two communities within the metropolitan Boston area, that were found to be vulnerable to increased coastal

flooding from our previous analyses (Frumhoff et al., 2007; Kirshen et al., 2008b; Watson, 2007). Neighborhoods within both communities are also categorized as Environmental Justice Communities as defined by the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA fact sheet; http://www.mass.gov/Eoeea/docs/eea/ej/ej_factsheet_english.pdf, accessed August 30, 2010); "neighborhoods (U.S. Census Bureau census block groups) that meet one or more of the following criteria: the median annual household income is at or below 65 percent of the statewide median income for Massachusetts; *or* 25 percent of the residents are minority; *or* 25 percent of the residents are foreign born, *or* percent of the residents are lacking English language proficiency." In addition, these particular communities were selected because of previously established relationships between the community organizations and project team members. The locations of these communities are shown in Figure 2 and are described as follows.

2.1.1 East Boston

East Boston is one of the 21 neighborhoods of the City of Boston. It covers an area of 4.5 mi^2 and is essentially a peninsula bordered by tidal portions of Chelsea Creek, the Mystic River and Boston Harbor (see Figure 1). Large portions of East Boston were created by filling in the area between several islands during the 19th century. The southeastern half of East Boston is dominated by Logan International Airport (Figure 2). The region was originally a center of shipbuilding. It is now predominantly a residential area with some industrial and commercial activities, particularly along the coastal fringe. Buildings are a mixture of old and new. Since 1840, East Boston has been, "by turns, largely Irish, Jewish, and then Italian for most of the 20th century. In recent years, East

Boston has welcomed a growing Latino population" (BRA, 2003). In 2000, the population of East Boston was 38,413 (6.5 percent of total Boston population) and a poverty rate of 19.5 percent, identical to that of Boston as a whole (BRA, 2003). Forty-two percent of East Boston residents were foreign-born, and some 60 percent of these have entered the United States after 1990. The Latino community, in particular, has seen well over a 158 percent increase during that time. Nearly 40 percent of the population speaks only Spanish at home; and approximately 23 percent of the population is considered to be linguistically isolated (http://www.noahcdc.org/about/index.html, accessed July 23, 2010).

Our particular study area was the Eagle Hill area, an EJ neighborhood within East Boston (labeled in Figure 2), Much the East Boston coastline is within a state Designated Port Area (DPA), which has important implications for future climate change adaptation strategies. According to the Massachusetts General Law, Chapter 91 (Public Waterfront Act) and their implementing regulations at 310 CMR 9.0, within DPA's, the central principle is to promote water dependent industries and to avoid the conversion of these areas to incompatible residential, commercial, and recreational uses. The City of Boston has zoned much of this waterfront consistent with this objective. The state Waterways Regulations govern the licensing of structures and uses in DPAs. These regulations strictly limit the placement of fill or structures in DPAs to only water-dependent industrial, accessory uses and a limited amount of supporting uses on filled tidelands. Thus some adaptation actions would have to be coordinated with Massachusetts Waterways Regulations for DPAs. This presents both opportunities and challenges; the opportunity is that new DPA activities could include adaptation to climate change, the

challenge is that the community does not have complete control over its local land use.

2.1.2 Everett

The other study area includes neighborhoods of the City of Everett (Figure 1). Everett was settled in 1630, established as a town in 1870 and incorporated as a city in 1892. Everett has a population of just over 38,000 and a land area of 3.36 mi^2. About 35 percent of Everett's population was between 25 and 45 years of age in 2000 (US Census Bureau, census 2000). Although predominantly white in 2000, Everett has served as a gateway city to immigrants for most of its history. African Americans make up 7.5 percent and Latinos 9.5 percent of its population. The community has a diversified industrial and commercial base with manufacturing accounting for approximately 31 percent of all jobs and more than 35 percent of the total annual payroll, followed by services and retail trade (http://www.cityofeverett.com/Everett_files/facts.htm, accessed on Mar 18, 2011). While the labor force has remained nearly constant over the last decade, the unemployment rate has increased dramatically, varying roughly between 3 and 5 percent from 2000 through 2007, then increasing to 9.1 percent in 2010. The minority population of Everett is 25 percent and the median household income is $40,661. Twenty-two percent of the population is foreign born and approximately one-third of foreign born residents are Hispanic. About 59 percent of residences are renter-occupied and 41 percent are owner-occupied. The waterfront area of Everett is dominated by commercial and industrial land uses. Everett is home to major petroleum, natural gas and food distribution centers serving Boston and New England and also to a 1600 megawatt electric generating plant that serves the Boston metropolitan area. Unlike East Boston, Everett has a convenient and accessible location, abutting the Mystic River

across from Boston and close to major interstate highways.

2.2 Map preparation

In order to assess increased vulnerability, we created maps of the extent of coastal flooding under selected climate change scenarios following the methodology presented in Kirshen et al. (2008b) using SLR projections by Vermeer and Rahmstorf (2009). At first, we developed maps showing flooding related to a 100-year coastal flood (estimated in Kirshen 2008b) under a lower emissions scenario (SRES B1; eustatic SLR projection ranged from 81 to 131 cm above the 1990 sea level) and a higher emissions scenario (SRES A1Fi; eustatic SLR projections ranged from 113 to 179 cm) in 2100, as we had done in previous studies (Frumhoff et al., 2007; Kirshen et al., 2008b). However, our contact at NOAH considered these maps too alarming. We also realized that the "century-scale" timeframe was well beyond the typical time horizon considered by most residents. Instead, we developed maps of coastal flooding at 2030, 2050 and 2070 by interpolating from the Vermeer and Rahmstorf (2009) curves. The interpolated eustatic SLR projections and land subsidence heights were added to the elevation of mean higher high water (1.45 m) and the 100-year storm surge height (1.49 m) estimated from Kirshen et al. (2008b).

2.3 Community workshops

The research into the community's adaptation incentives and obstacles was accomplished in three workshops with residents of each community. The workshops were organized by the authors and participants were solicited by the collaborating advocacy groups: the Neighborhood of Affordable Housing (NOAH), nonprofit multi-service community development corporation headquartered in East Boston and La

Comunidad, a nongovernmental organization (NGO) in Everett. Workshops were held in the evening and generally, as requested by us, the same set of participants from each community attended all the workshops in that community.

Workshop One. The goal of the first workshop was to elicit the participants' cultural knowledge about climate change and impacts. By cultural knowledge, we mean the explicit and implicit beliefs and values that participants use to understand climate change. This approach is rooted in the theories and methods of cognitive anthropology, here applied to environmental issues (cf. Paolisso, 2003; 2007). To elicit cultural knowledge about climate change, with the longer-term research goal of linking such knowledge to adaptive capacity, we used a series of systematic data collection approaches, specifically free listing, pile sorting and multidimensional scaling (Borgatti, 1996; Weller and Romney, 1993). We first asked participants to freely list the words that come to mind when they think about "climate change." This was an open-ended exercise; we did not attempt to guide or direct their responses. Next, we asked the participants to identify the most important words, which allowed us to cut the list of words to a manageable number (approximately 50 words). Finally, we asked workshop participants to group these words into piles of related terms (“pile sort”). Pile sorting is an easy and useful way to collecting information on similarities and differences in knowledge and values (Weller and Romney, 1993). Again, we did not provide any criteria for judging similarity or dissimilarity, but rather we wanted participants to use their own cultural criteria to group terms. Multidimensional scaling (MDS), the last step of the analysis, was performed after the workshop. This is a set of techniques that help researchers uncover the "hidden structure" of data by analyzing proximities within the data itself

(Kruskal and Wish, 1978).

Workshop Two. The purpose of this workshop was to discuss the MDS results, to present an overview of scientific understanding of climate change and to elicit participants' preliminary responses with respect to the possible adaptation options. After presentation of the flood maps (describe in Section 2.2), we began a discussion about options for adaption to increased flooding due to climate change. We presented the four categories of flood protection: no action, protection, accommodation through floodproofing and evacuation planning, and retreat and then elicited general discussion from participants with respect to the feasibility of these options within their communities.

Workshop Three: The third and final workshop in each community focused on community incentives and obstacles to specific adaptation options that we presented to them, since they were not familiar with adaptation possibilities. In East Boston, to focus the discussion, we presented conceptual images of some options which were designed to be flexible so they could be adjusted to SLR changes over time. These included a modular sea wall (see Figure 2), building a beach and dune system to protect a presently exposed coastal area, the building up of a present beach with geotubes to provide additional flood protection and various types of wet and dry floodproofing. The beach concepts would provide amenities now as well as protection later. After the presentation of options, the participants were divided into four groups with a moderator to discuss the following questions:

1. Which of the adaptation options seems most feasible/attractive ?
2. Which options would you object to and why?
3. What obstacles are in the way to getting the options in place?

4. What needs to happen to make adaptation a reality?

In Everett, due to the more indirect impacts of flooding upon community members, the discussion was broader and related to how indirect impacts would affect the residents and options that they might have for coping with these impacts. In the next section, we will discuss the results of this workshop series in each community and compare and contrast the meaning of our findings.

3. Results and Discussion

3.1 Workshop1: Cultural knowledge about climate change

The first workshop in East Boston was held on the evening of March 9, 2009 and was attended by 26 community residents, about two-thirds of which were Spanish speaking. Consent forms for voluntary participation and permission to audio tape were explained to participants by the workshop leader and then signed by the participants. Sequential translation (lines presented first in English and then in Spanish) was offered by the directors of the NGOs. Participants were asked to list all words that came to mind when they think of the term “climate change”. A total of 74 words were mentioned and recorded on flip charts and participants were provided "post it” notes to rate those words that they thought represented impacts that were most important. Again, we did not ask for any explanation, so as not to bias their cultural thinking about the terms and their importance. We reduced the list of 74 words to 47 based on this rating; a few synonyms were included in the final list. After this exercise was complete, we asked participants for their thoughts about our process and general ideas about climate change. It became clear that many of workshop participants were actively engaged and deeply invested in their community and reasonably well educated on the issues and complexities of climate

change. However, this may have been due to the fact the director of NOAH, who advertised the workshop and invited the participants, had targeted those whom she already knew were active in the community and on environmental issues.

The first workshop in Everett was held on the evening of December 10, 2009 and was attended by 30 community residents, the vast majority of which were Spanish speaking. The same procedure was followed (first consent, then introductions, then word listing-pile sorting exercise). Over 60 words were listed of which 41 were mentioned by four or more participants; these terms were used in the pile sorting exercise and later MDS analysis. Figures 3a and 3b show the results of the MDS analysis of word list-pile sort activity for East Boston and Everett, respectively. These plots were generated using non-metric multidimensional scaling tools of the software program Anthropac V4.0 (Borgatti, 1996). Word that are plotted closer together were on average placed in the the same pile by workshop participants, suggesting that they see the words as more similar than words in other piles. While there are differences in the words elicited for both East Boston and Everett, there are some general commonalities across the two MDS plots. Participants in both communities identified a number of drivers of climate change. In East Boston, participants identified such causes as emissions, pollution, and carbon dioxide, (Figure 3a), while in Everett deforestation, green house gases (Figure 3b). Most words for both communities fell into a category that can be labeled large-scale environmental impacts. For East Boston, a cluster of words such as changing atmosphere, melting glaciers, rising sea level, flooding, drought, fires, disaster, devastation, etc were elicited (Figure 3a). For Everett, participants mentioned large-scale impacts such as fires, volcanoes, polar cap, landslide, wind, rain, flooding, storms, etc.

(Figure 3b). A third cluster of words in both plots include perceived social and health-related impacts of climate change. The East Boston MDS plot includes terms for social impacts, including insecurity, discrimination, war, poverty and violence, and health impacts such as asthma, sickness, death, famine, epidemic (Figure 3a). For Everett, the social impacts mentioned include immigration, fears, extinction, hunger, and more bio-medical impacts included infertility, illness and epidemics (Figure 3b)

The terms and their clustering in Figures 3a and 3b support a number of observations that are relevant for both communities' opportunities and constraints in terms of adaptation to climate change and SLR. First, many of the elicited causes and consequences or impacts are not scientifically established or at best could be a number of indirect links away. The veracity of specific terms is less important than the overall pattern of clustering. First, participants are clearly conceptualizing climate change as initiating a series of environmental and human impacts. In both plots, however, there are not many terms that capture the causes, though East Boston does have a number of terms related to causes (e.g., emission, carbon dioxide). In our discussion with workshop participants after presenting the MDS results, it became clear that participants did not have much scientific-based information on the causes of climate change and resulting SLR (which is why they greatly appreciated our presentation on the topic in Worshop 2). Where participants did have more information was on the impacts of climate change, regardless of the extent and veracity of their understanding on the causes. In both MDS plots, many terms were listed for environmental impacts. Many of these impacts have not been scientifically linked to climate change, though more than a few have been (e.g., flooding, storms, melting glaciers, drought, hot, storms, rising sea level). Again East

Boston participants generated more environmental impact terms relative to Everett, which maybe due to the information and outreach work of NOAH. Finally, participants in both communities provided words that suggest they understand that climate change will have a wide range of social and health impacts. The scope and breadth of these impacts is impressive: greed, insecurity, war sadness, illness, asthma, famine, etc. (Figures 3a and 3b). Again, while not scientifically proven, the range of human impacts mentioned by participants is noteworthy for the possibility that participants see a very ominous and catastrophic future associated with climate change. Given the above results, it is important to reiterate that the results of the MDS should not be judged as "right or wrong" according to scientific knowledge, but as representative of the cultural beliefs and values participants draw upon to help them understand climate change. This cultural knowledge is derived from shared experiences, both here and in regions from which participants have emigrated.

The MDS plots also are informative in terms of what terms were not mentioned. While participants from both communities mentions broad responses such as reforestation, trees, Kyoto Accords, green alternatives and even Al Gore, there was no mention at all of specific adaptation strategies, in particular to flooding and SLR. In our discussions with participants during Workshop 3, it became very clear that participants have almost no knowledge of possible adaptation strategies, or the local government or non-government agencies that could assist them. . The “take away message” from this analysis was a general lack of understanding about local impacts or responses to climate change. This is the first barrier that must be overcome to develop effective adaptation plans.

3.2 Workshop 2: Local impacts of climate change and the concept of adaptation.

3.2.1 East Boston

The second workshop in East Boston was held on April 27, 2009. There were 30 participants in this workshop. Many but not all of the participants had attended the first workshop. Joining us at the workshop was a representative from the City of Boston, because he was interested in knowing how the residents would react to the information that we presented. At the beginning of this workshop, we presented preliminary results of the MDS analysis, noting the way the words had been grouped together and possible explanations as discussed in Section 3.1. We then presented a brief overview of climate change science, presenting a graph of long-term climate records, how these records are developed from ice cores and an overview of climate change impacts that have observed in New England. We went into more detail about the causes of sea level rise (thermal expansion, ice melt, and vertical land movement) and projections of how sea level could change under the two selected climate change scenarios. Figures 4a and 4b show the extent of flooding in East Boston due to a 100-year coastal storm in 2030, under lower emissions and 2070, under the higher emissions scenario, to bracket the range of flood maps we developed for this workshop. As would be expected, there was a great deal of reaction to these flood maps. After the presentation of the maps, we then gave a brief overview of the four general adaptation options: 1) no action; 2) protection; 3) floodproofing and 4) retreat. All agreed that the "no action" scenario was unacceptable, but the biggest issues related to all options were that of cost and accessibility. Building a sea wall was mentioned as an example of the protection option, but this elicited a visceral response. The concern with this option was that there are already many problems that

residents have to deal with living in East Boston (proximity to Logan Airport, limited public transportation, and congestion being some of the biggest) and the one positive attribute was their access to the water. Residents viewed a sea wall as completely blocking their view and access to the waterfront. To the "retreat" option, there was a resounding, collective "NO!" Participants expressed their cultural roots and sense of community as East Boston residents and that they would not consider leaving this area. With respect to the option of "floodproofing", the general consensus was "who would pay for this?" Many residents are renters and were concerned that landlords would have no incentive for floodproofing their buildings. We also discussed temporary evacuation as an option, but participants noted that many of them would have no place to go. Their families and friends are all in East Boston and they would not be able to afford to live in hotels outside of the flooded areas. Perhaps expand more upon these using the book chapter or refer to the book chapter. We could also shorten and synthesize by placing the responses in a table. That would also be good for eventual power point presentations.

3.2.2 Everett

The second workshop in Everett was held on April 16, 2010; twenty participants attended. We followed the same format as in East Boston, first discussing the results of the MDS analysis and then presenting an overview of climate change in general, and sea level rise in particular. Figures 5a shows the flooding in 2030 under the lower emissions scenario and Figure 5b shows flooding in 2070 under the higher emissions scenario, bracketing the extent of flooding we presented to the residents. The residential area of Everett is well above the flood elevations. No one at the workshop lived in the affected area and only a few knew people who did. As before, we discussed adaptation options

with the residents, but in general, there was little connection to this idea because the residents themselves would not be affected directly. However, we did discuss the many ways in which flooding in the commercial and industrial areas would disrupt jobs, transportation into and out of the city and could lead to environmental contamination.

3.3 Workshop 3: Incentives and obstacles to community implementation of adaptation strategies.

3.3.1 Final East Boston workshop

The final workshop in East Boston was held on March 29, 2010. Coincidentally, this meeting was held during the third of three successive large rainfall events in as many weeks that occurred in March 2010, and so flooding was on everyone's mind that evening. Forty participants showed up, which was by far the largest attendance of any of our workshops. We first gave an overview of the information presented as the second workshop and then began talking in more detail about adaptation options. The first option we discussed was evacuation and we showed the map of evacuation routes and evacuation centers in East Boston shown in Figure 6. This clearly indicated that the current evacuation plan for the city of Boston is inadequate for the future because, by mid-century, both evacuation routes and centers would be flooded in an extreme coastal storm under both lower and higher emission scenarios. Adapting the evacuation plan for East Boston will be covered in more detail in an upcoming paper. After discussing evacuation, we then presented more detail on the types of floodproofing that is available for residential buildings and we showed the conceptual images for the sea wall and beach designed by WHG and also reiterated the retreat option. We then divided the participants

into 4 groups so that they could discuss these options and answer the four questions outlined in Section 2. Each group had a facilitator who transcribed the discussion as best as possible. Following is a summary of these answers.

1.Which of the adaptation options seems most feasible/attractive ?

Generally, most supported the concepts of utilizing natural ("soft") approaches as much as possible. This would include beach systems as well as restored wetlands. The advantage of "soft" barriers is that flood protection can be combined with neighborhood amenities, such as green space. Overall, there was more acceptance of the modular sea wall as an option in some places, which was a very different reaction than during the second workshop. This attests to the power of images in conveying an idea. Some supported the concepts of floodproofing by wet and dry methods as appropriate. Very few supported elevation of existing buildings. Only a few supported evacuation as an option. Some suggested using the facilities at the nearby Logan Airport as an evacuation site; part of the airport terminals are relatively high and they have food preparation and water and toilet facilities. Tour boats such as "Duck" boats could be used to ferry residents, if necessary. Others brought up the concept of connecting the chain of islands in the harbor with an opening hurricane barrier. A number of participants recognized that it may be possible to implement some adaptation measures against coastal flooding that also protect against another climate change threats such as increased local drainage flooding from more intense rainstorm.

There was some discussion prompted by one of the facilitators about when the group recommends action be taken? Does it makes sense to adapt now or wait? Some remarked that actions should be taken now to avoid a situation like the flooding during

Hurricane Katrina. Others were willing to wait until had more information but agreed with the facilitator that options for future actions need to be preserved now. All agreed that community members need to be a part of the planning process.

2. Which options would you object to and why?

Every option had some objections. Protection based upon sand systems faced the threat of loss of stability and erosion. Sea walls were generally considered unattractive and block views (though there was some discussion of the trade-offs of views and safety). Dry floodproofing with tarps around the basement might be difficult to implement. Elevation of some buildings would be unattractive and difficult because many buildings are attached to each other. There are also many basement apartments making any kind of flood proofing difficult. In addition, since many rented their residences, they were not able to carry out these options. Evacuation was a concern because of the resulting traffic jams, the costs of staying outside of their residents for any period of time, most residents not having cars, and a significant number of disabled and elderly people. Many people would stay to protect their property. Permanent retreat is not seen as an option because of desires of residents to remain close to family and friends and general difficulty of obtaining low priced housing; “permanent moving should not be on the table… People in East Boston have a real identity and roots… there needs to be a better plan for staying here.” Some acknowledged that living close to the coast presented a special set of risks that must be recognized.

3. What obstacles are in the way to getting the options in place?

All the workshop participants mentioned that cost was a major obstacle for the community taking action. Costs for individuals would be high and landlords would be

unwilling to invest in floodproofing rental units because of possible lost of rents from lower units. Other obstacles to evacuation besides those previously described include some having no place to go – no family or friends within 10 miles inland. Evacuation preparation time of 24 hours would also be an obstacle. Another obstacle was the need to redefine the evacuation routes after the next few decades so they would be passable – if that was possible. Other obstacles included the need to coordinate flood protection from multiple sources – for examples from areas outside of the neighborhood and the drainage network also backing up – both possibly negating any local adaptation defenses. Participants also mentioned that dealing with the local municipal bureaucracy was very difficult. Interestingly no one mentioned current floodplain management policies of the City, the state, and the federal government. Also, no one mentioned that much of the East Boston coastline is a Designated Port Area.

4. What needs to happen to make adaptation a reality?

Some suggested that the City of Boston fund and build large protection projects that protect many residents because many homeowners and landlords will not will pay to take steps to protect individual residences. Perhaps also all new buildings should be floodproofed and zoning has to be improved to formally incorporate consideration of future sea level rise vulnerability. Most participants agreed with the suggestion of one participant that one of the first actions has to be for all to recognize the challenges of climate change and then for the community to participate in the planning process - "So they don't feel powerless". Several factors were seen as important to accomplishing this. There is the need to educate a broad range of stakeholders. More information on climate change is key. Community groups need to become more involved by helping negotiate

between the City and the community, between landlords and renters. Participants offered to go out and each talk to 2 to 3 people about climate change in East Boston. The goal is for "people (to) get concerned and start taking prevention measures."

Therefore the East Boston research can be summarized as below:

- The residents profess to having little power over the management of their community. They are generally renters with very limited economic, political or social resources. It appears that the adaptation decisions will be made by processes, institutions and individuals who are between these community members and the climate change impacts, eg., state regulatory program for Designated Port Areas the Boston Redevelopment Authority, and other city agencies, and landlords.
- All options have some disincentives for them; with high costs being common to all. Permanently leaving the area is the least attractive. Even though most of them are recent immigrants, they have strong ties to each other and to the concept of remaining together. Their cultural knowledge may limit their viewpoints on alternative locations or communities to live in.
- Participants believe they need more information on climate change, how it will impact them, and what resources are available to assist them. Thus even though there have been many reports on climate change and the need for local participation in adaptation (IPCC, 2007; USCCSP, 2009; NRC, 2010), this information has not reached this community or yet resulted in locally driven adaptation planning.

  On the other hand our research uncovered many incentives to pursue adaptation planning with this community.
- They have a very broad ranging view of climate change impacts, as evidenced by the

free list, pile sorts and MDS results. They do not appear to be climate change naysayers. Their very holistic view of possible climate change impacts, while not science-based, is a good platform for further education and learning about the multiple connections between climate change and a range of impacts).

- They are committed to their communities, out of choice and also a lack of other housing options; they don't want to leave; it appears that they want to stay. They also recognize coastal living presents special risks.
- Participants prefer options that enhance their present environment and will not require evacuation or permanently leaving the area. Further research into the social, economic and environmental aspects of various kinds of adaptation options is necessary to determine if it is possible to meet this preference and if not possible in all cases, then other acceptable options must be found.
- At the end of the workshops the participants seemed less powerless than during the first workshop and wanted to take action. In other words, this community, while not in main stream of the decision making process, once they become educated and engaged in this issue, are willing and able to become a part of the decision making process

3.3.2 Final Everett workshop

The final workshop at Everett was held on April 21, 2011 and thirty participants attended. Again, we reiterated the information shared at the second workshop including the flood maps. In this case there were a couple of participants who do live in an area that would be flooded. Because there was so little impact on the residents themselves, we did not ask the same questions as in East Boston. Instead, we focused more discussion on

what the MDS plots said about residents' understanding of climate change and impacts. Impacts noted by some participants included economic and emotional. Residents' ability to get to their jobs and to other parts of Boston would be disrupted. Also, they noted that one of the facilities that would be flooded is a food and produce distribution center for much of New England, suggesting that this type of event could have far reaching impacts. They also noted that this end of Everett was central to gas distribution for the region and that there are several large power stations in the area vulnerable to flooding. So in contrast to East Boston, where most of the impacts would be felt locally, the impacts of increased flooding in Everett could have dramatic effects on food and energy distribution and potentially large economic impacts for the region.

The workshop concluded with a discussion of the necessity of this type of meeting to 1) educate residents on climate change and local impacts and 2) facilitate connections between residents and also with decision makers so that they could be involved in developing solutions. The obstacles and incentives to climate change adaptation in Everett were similar in that there was a general lack of understanding of local climate change impact, but once residents were made aware of the potential impacts, they were very engaged and eager to be a part of the solution. One major obstacle in Everett is the fact that the areas most vulnerable to increased coastal flooding are industrial and commercial land uses, and it may be more difficult to engage these stakeholders in adaptation planning. The impacts of sea level rise will likely be felt more indirectly by residents in Everett than in East Boston, but these impacts will be felt keenly in the metropolitan area and the region because some of the affected areas in Everett are important centers of regional economic activity. This could be the impetus

for greater participation in adaptation planning by city, state and regional officials.

4. **Summary and Conclusions**

We explored the possible impacts of increased sea level rise and potential adaptive responses of two urban, environmental justice communities (East Boston and Everett) within the metropolitan Boston area of Massachusetts. While these two communities have similar socioeconomic characteristics, they differ substantially in the extent to which residents would be directly impacted by increased coastal flooding. In East Boston, a large portion of residents would be flooded, while in Everett, it is the commercial/industrial districts that are primarily vulnerable. The Everett residents pointed out that since many of these commercial and industrial activities serve the region, the regional impacts could be greater than impacts on the residents, who are generally at higher elevations. Our findings indicate that there exist a myriad of social and cultural obstacles to adaptation in these communities that limit their adaptive capacity. The MDS analysis indicates that populations within both the communities we studied do not have an adaptation perspective or knowledge of any resources that could assist them in this challenge. This presents an opportunity for future work in that educating residents about climate change and options is key to empowering them to act on their own behalf. The plots did, however, indicate they are aware of some of the local and global impacts. A further line of research inquiry is that perhaps this is common for recent immigrant groups that have a tradition, present or in their past, of being dependent on nature and subject to unmanageable natural disasters such as floods, storms, and earthquakes. Religious values should also be further explored. Their lack of knowledge of local adaptation options may reflect their feelings of powerlessness in the US. It may also

reflect the wider lack of knowledge of adaptation options among all types of communities in the United States because it is only since 2009 that the US government has acknowledged the inevitability of the need for adaptation planning. An additional obstacle for both communities is the residents need more information on climate change, how it will impact them, and what resources are available to assist them. Thus even though there have been many reports on climate change and the need for local participation in adaptation (IPCC, 2007; USCCSP, 2009; NRC, 2010), this information has not reached these communities.

On the other hand our research uncovered many incentives to pursue adaptation planning with this community. They have a very broad ranging view of climate change impacts, as evidenced by the free list, pile sorts and MDS results. They do not appear to be climate change naysayers. Their very holistic view of possible climate change impacts, while not science-based, is a good platform for further education and learning about the multiple connections between climate change and a range of impacts). While initially the participants had no or a limited concept of adaptation, at the end of the process they were eager to continue learning about climate change and recognized that there is the need for an integrated regional flood management strategy

Understanding existing cultural knowledge and values about adaptation to climate change must be part of the framework adaptation planning. Given the community's desire to move forward with adaptation and the present lack of local active engagement by government on adaptation here, we believe that a collaborative planning and learning process such as Joint Fact Finding (JFF) with local and institutional stakeholders is the next step for East Boston. In JFF, “stakeholders with differing viewpoints and interests

work together (with the technical team) to develop data and information, analyze facts and forecasts, develop common assumptions and informed opinion, and, finally, use the information they have developed to reach decisions together" (Ehrmann and Stinson, 1999, pg. 376).

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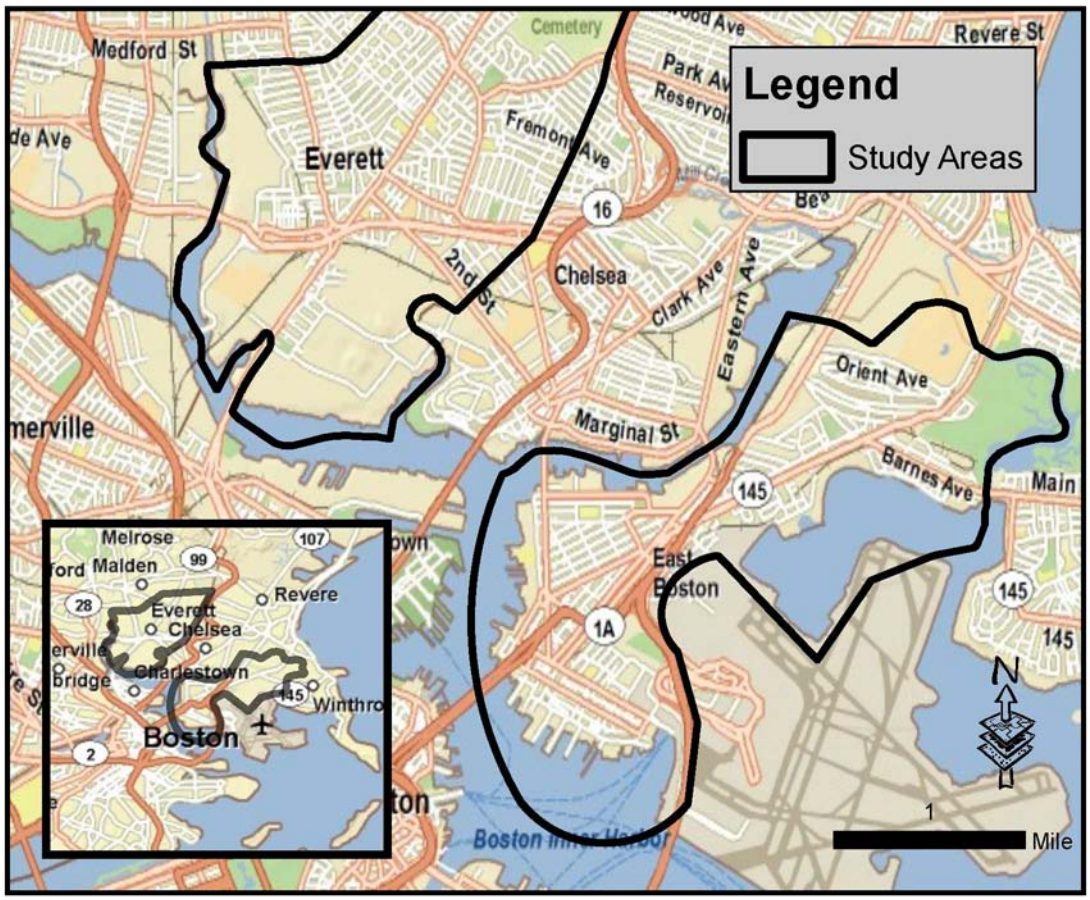

Figure 1: Study communities of East Boston and Everett, MA. Community boundaries are outlined in black. The roughly triangular-shaped area of East Boston known as Eagle Hill is labelled in red.

Figure 2: Conceptual modular sea wall design protection for a school and community center in East Boston.

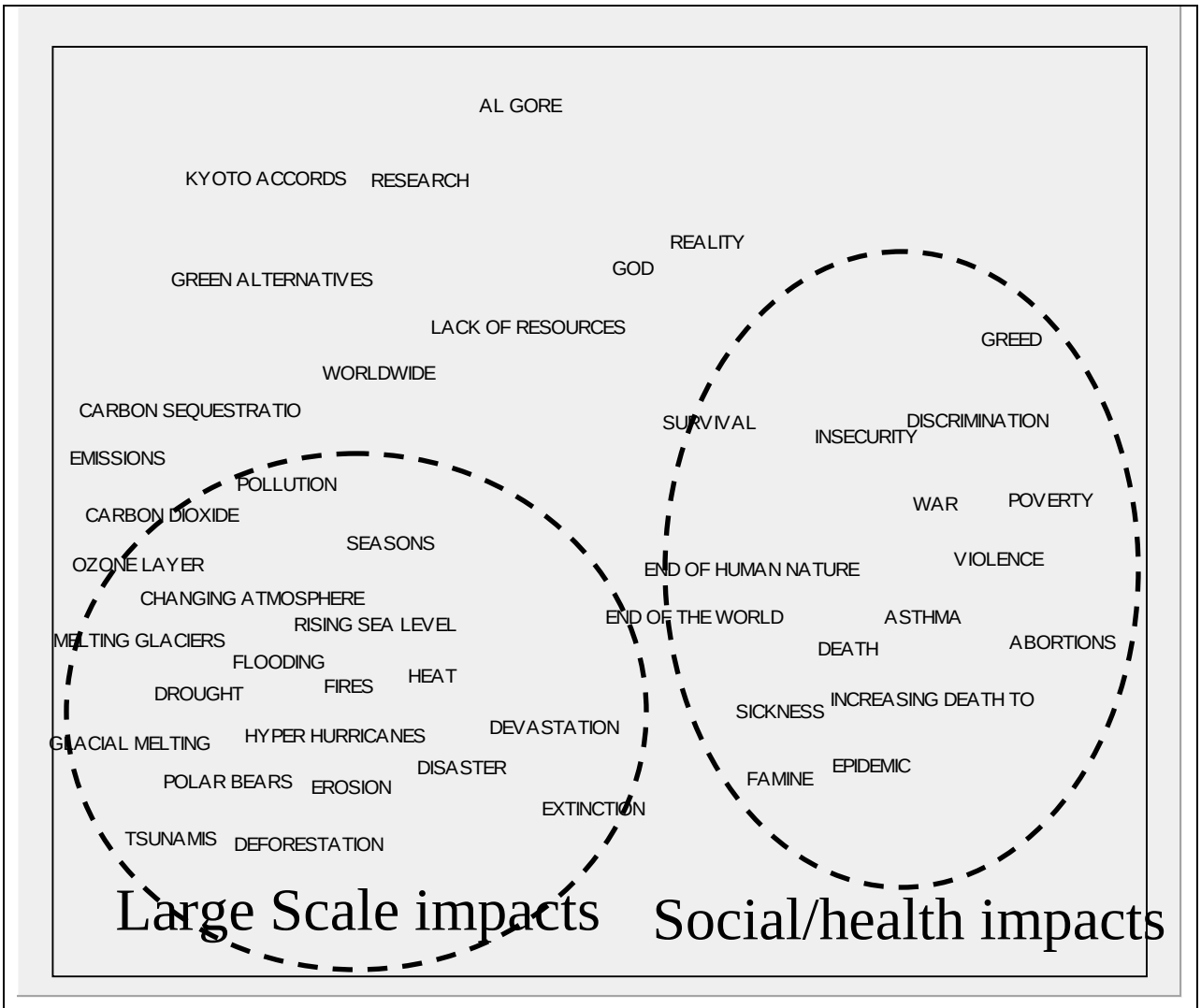

Figure 3a: Multidimensional scaling of pile sorting exercise from first East Boston workshop.

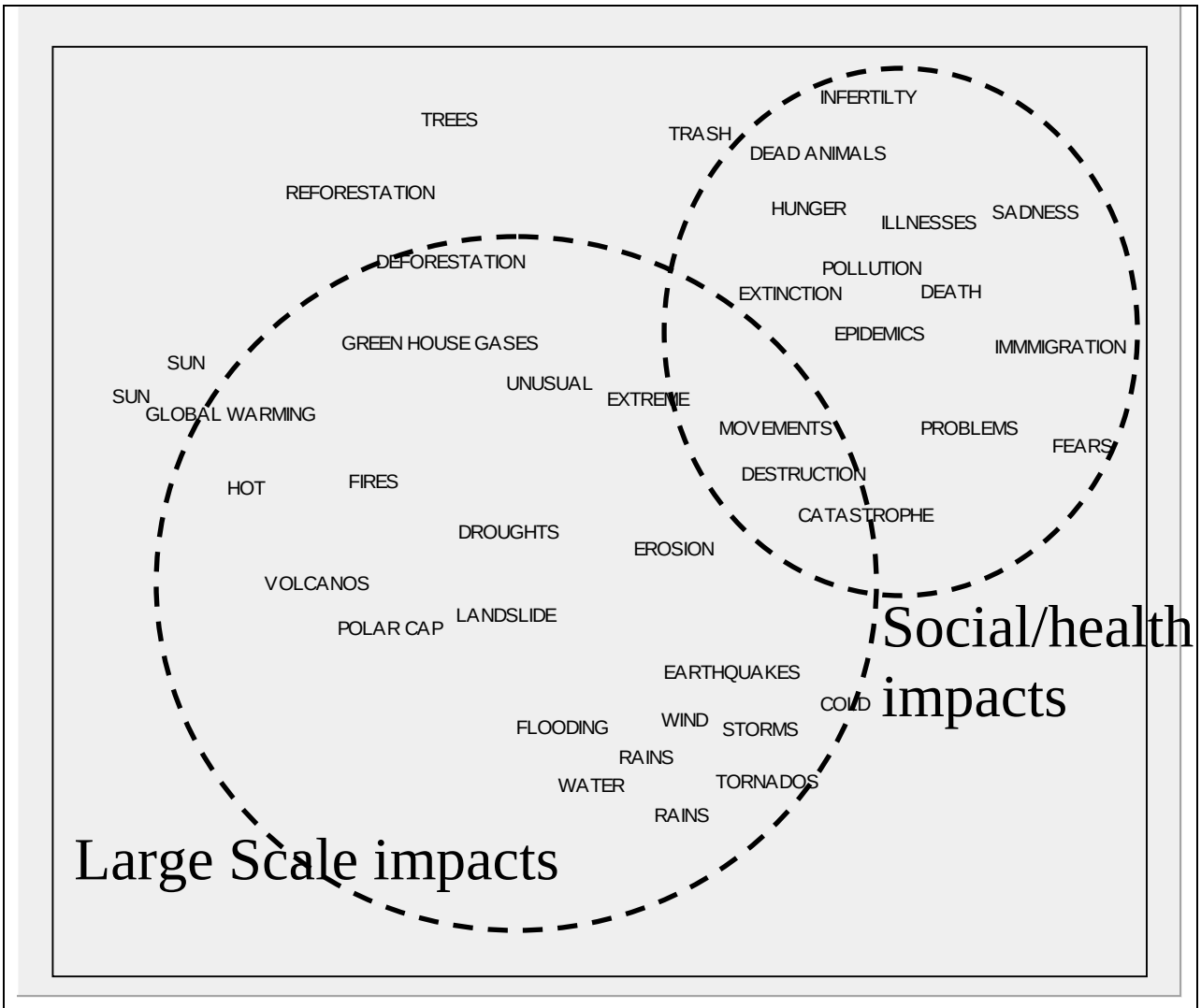

Figure 3b: Multidimensional scaling of pile sorting exercise from first Everett workshop.

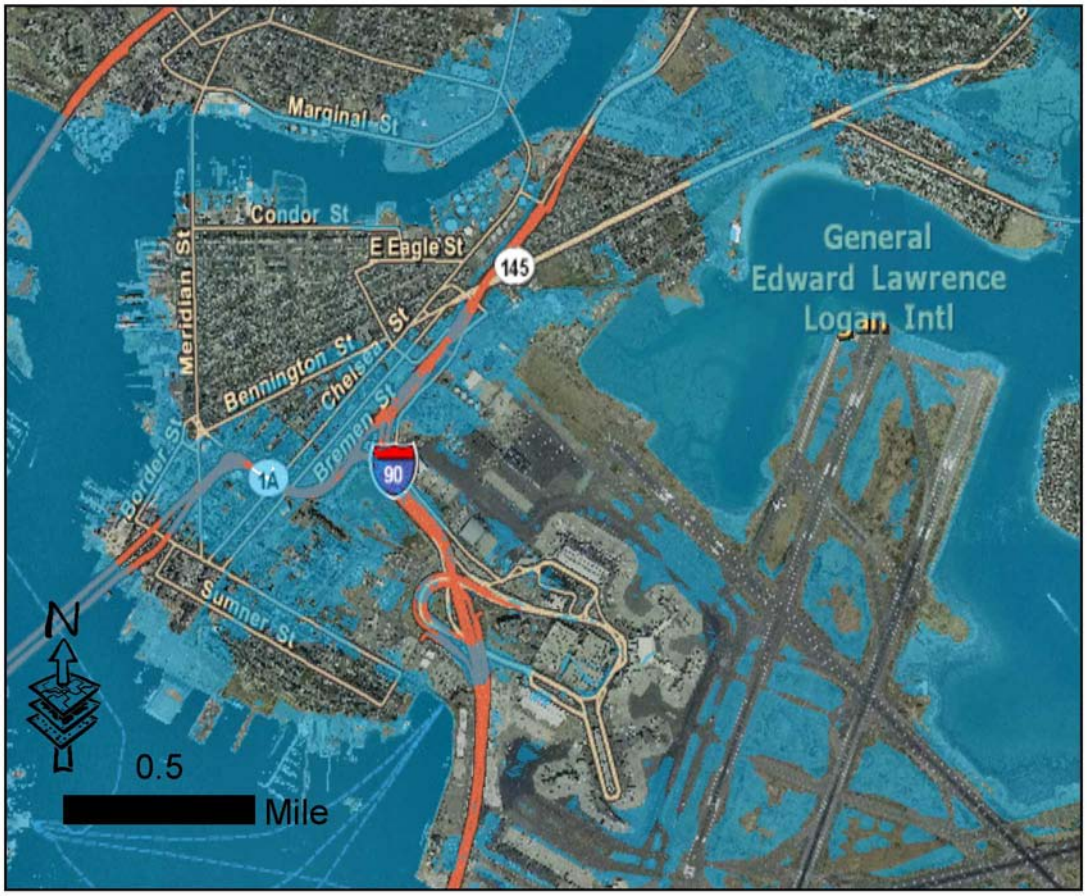

Figure 4a: Estimated extent of the 100-year coastal flood in East Boston by 2030 under the low emissions scenario. Note: this map was made prior to developing a method for assessing the connectivity of flooded areas to the ocean. Based on our current improved mapping method, some areas shown to be flooded on Logan Airport property (lower right quadrant of map), have been removed because a GIS analysis has shown no physical connection to flooding from the ocean.

Figure 4b: Estimated extent of the 100-year coastal flood in East Boston by 2070 under the high emissions scenario. Note: this map was made prior to developing a method for assessing the connectivity of flooded areas to the ocean. Based on our current improved mapping method, some areas shown to be flooded on Logan Airport property (lower right quadrant of map), have been removed because a GIS analysis has shown no physical connection to flooding from the ocean.

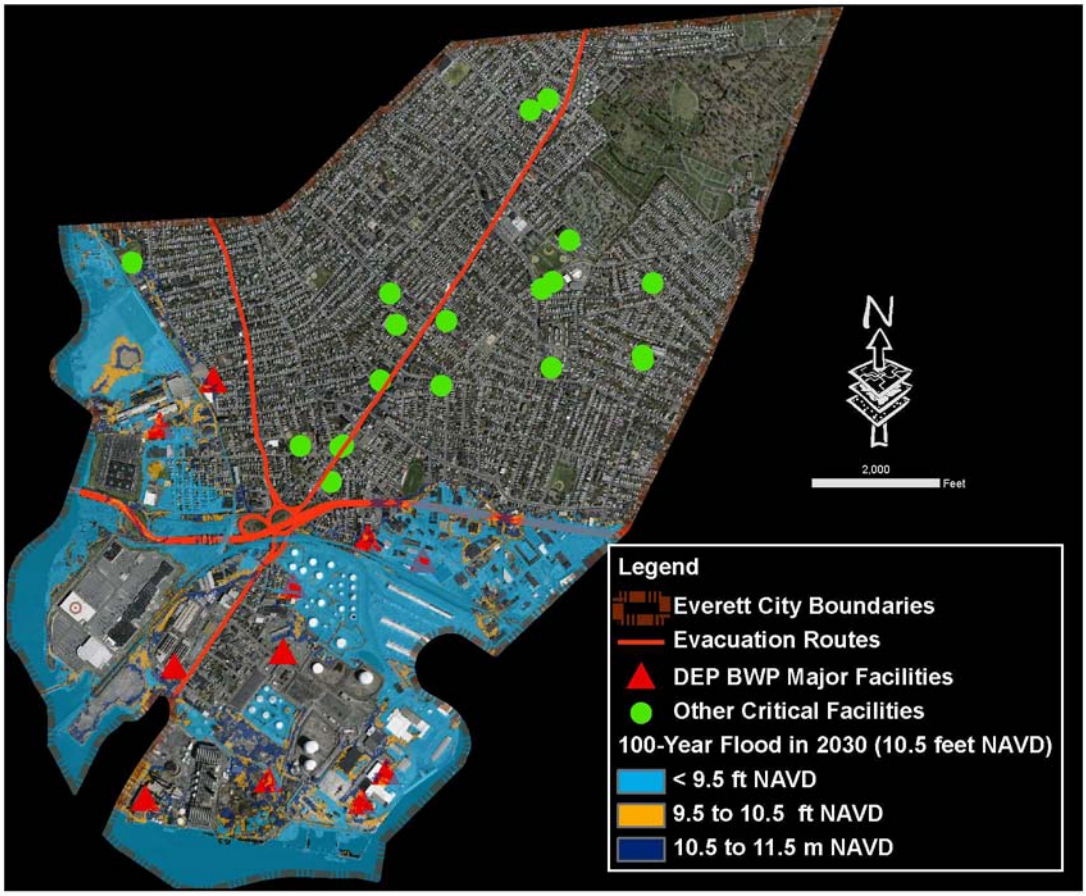

Figure 5a: Estimated extent of the 100-year coastal flood in Everett by 2030 under the low emissions scenario.

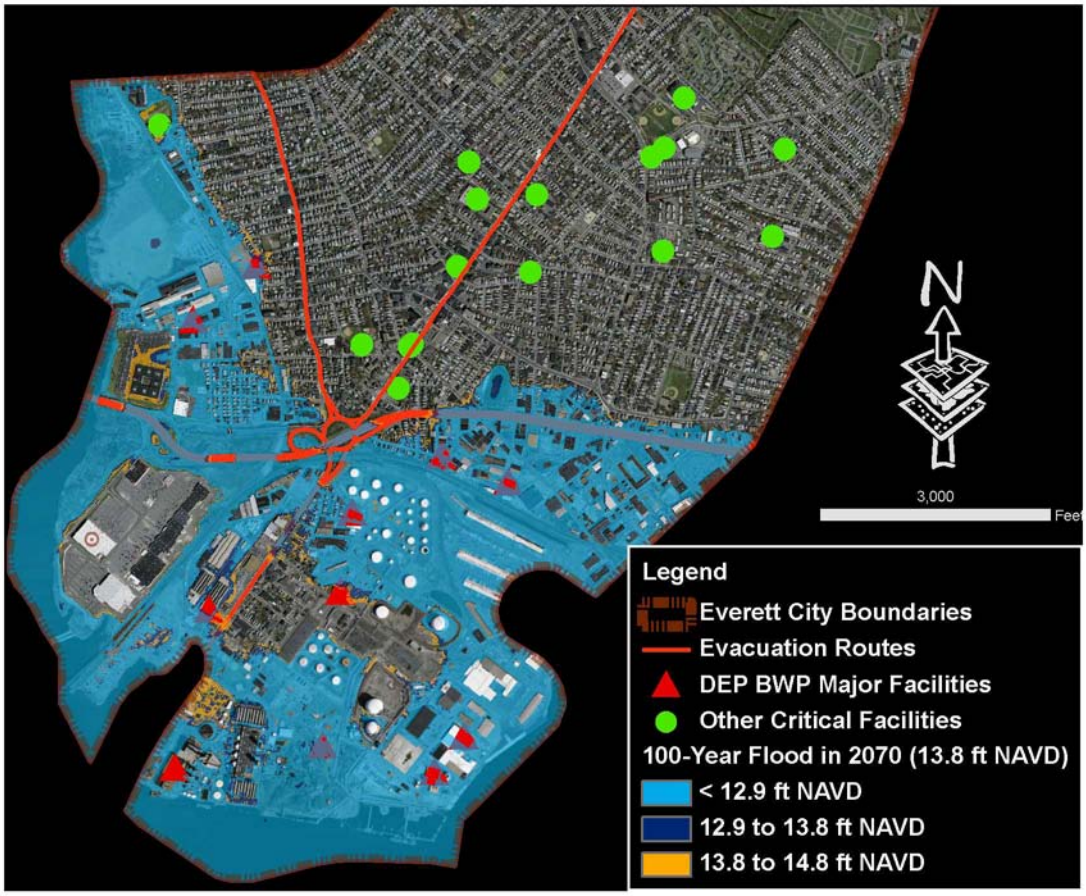

Figure 5b: Estimated extent of the 100-year coastal flood in Everett by 2070 under the high emissions scenario. Map has been magnified to better illustrate flooded areas.

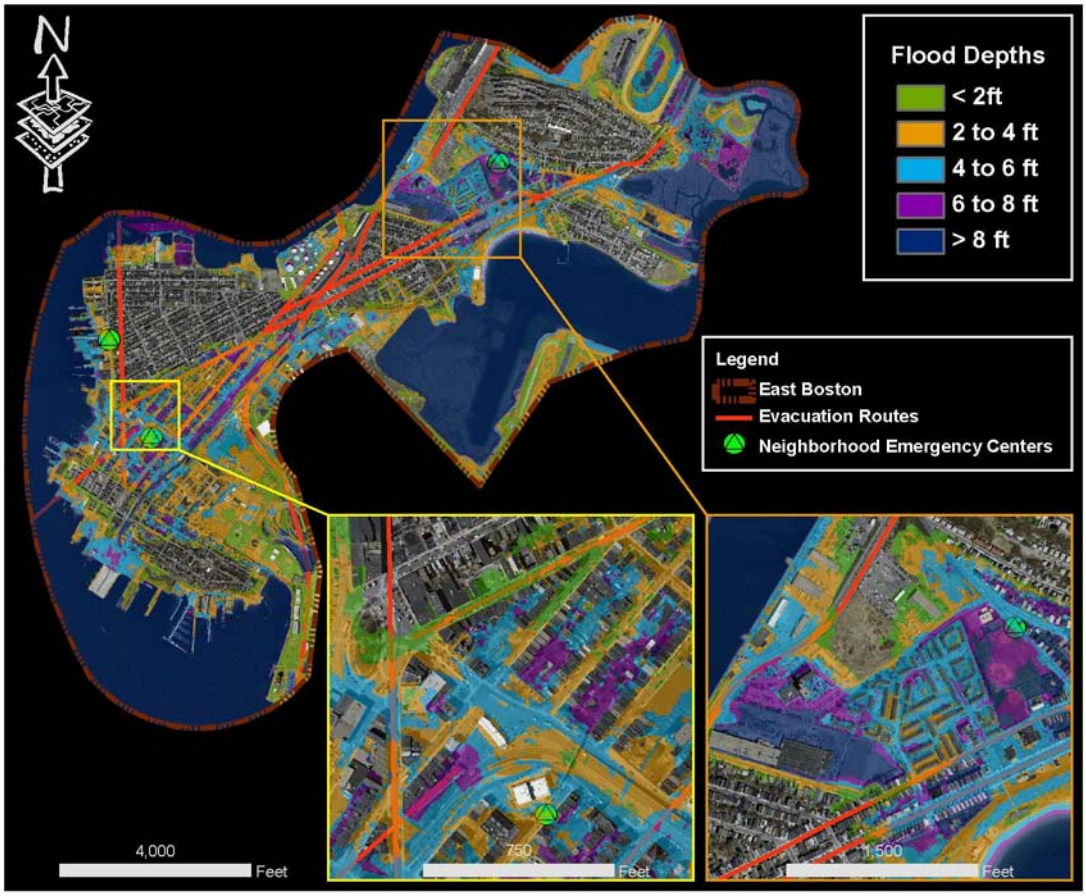

Figure 6: location of evacuation routes (in red) and evacuation centers (green symbols) relative to flooding due to the 100-year coastal storm under the higher emissions scenario. In this map, we also present color-coded flood depth intervals as shown in the legend.