Vulnerable Population Ranking Memorandum

Climate Change Vulnerability Assessment

City of Cambridge, Massachusetts

November 2015

CITY OF CAMBRIDGE CLIMATE CHANGE VULNERABILITY ASSESSMENT (CCVA)

Vulnerable Population Ranking Memorandum

Prepared by Kleinfelder, 05-2014

The social vulnerability index provides 'sensitivity' and 'adaptive capacity' scorings by which to rank the census tracts of Cambridge, using select indicators that have an established correlation with sensitivity and adaptive capacity in the vulnerability literature. This is part of a two-fold approach to rank social vulnerability factors by extending the Local Governments for Sustainability (ICLEI) [1] methodology most often used to rank infrastructure sensitivity and adaptive capacity. The use of geographic boundaries and census data offers one perspective on those individual and systemic vulnerabilities that can be understood with mapping tools. This analysis provides a limited but valuable geospatial evaluation of community risk. It is not intended to provide a comprehensive picture of the strengths and vulnerabilities of the City's residents and workers individually, or of the capacity of its existing service networks and community or faith-based groups, to meet the most pressing needs of the community during a weather-related crisis. No single assessment can quantify all the important aspects contributing to the social dimensions of vulnerability, but we believe that this approach will offer a clarifying picture of the service-based vulnerabilities we face, by neighborhood and census tract, that can serve to help us further understanding how our community will fare during extreme weather events.

Context / study's limitations

The project team acknowledges the several ways in which a population can be at risk – homelessness or dislocation, chronic ailments – and the particular needs of those who are on the spectrum of mental and physical disability, that have not been integrated into this report the project's approach does not attempt to elucidate the greatest driver of adaptive capacity, e.g. social cohesiveness and personable accountability among residents, workers and employers for those in need. These social networks certainly do not coincide with official boundaries and are highly dynamic and difficult to assess. On the other hand other social networks, e.g. faith and

[1] http://www.iclei.org/

community-based organizations and services supporting vulnerable populations in Cambridge are site-based and can be mapped and do, so some extent, serve as part of the network of associations and social supports that are likely to play an outsized role during an emergency. While the social vulnerability index employed in this assessment may not capture complex social support systems and regional service networks, the use of census tracts does provide a visual anchor point to describe important geographic aspects of social vulnerability and it serves as a useful starting point and a tool for further planning and assessment efforts. The City, its government, residents, institutions and businesses, can draw on this information to craft a more nuanced picture of the community as it engages in clear-eyed self-assessment and prepares for greater resiliency in the face of future climate-driven threats.

Methodology overview

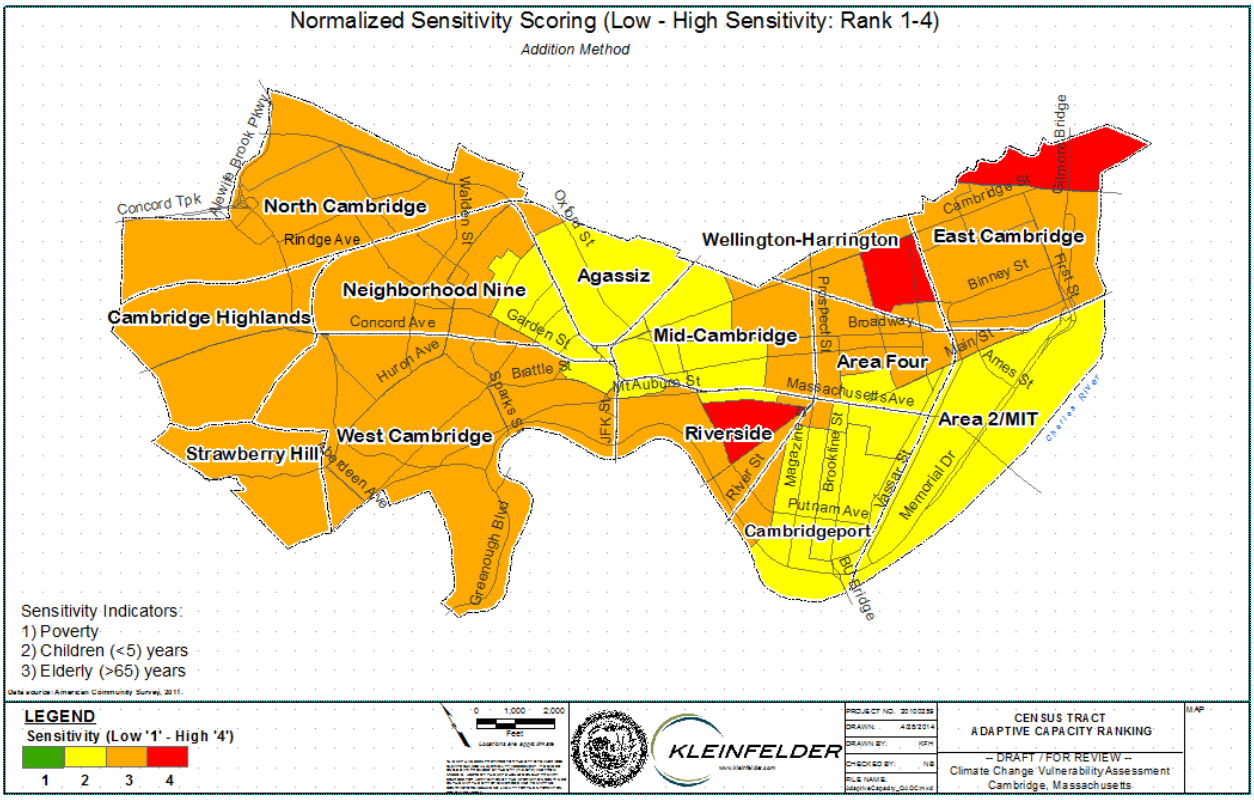
The sensitivity and adaptive capacity indicators are ranked by comparing Cambridge against itself. The resulting maps are useful, first-cut approaches to considering some of the ways we can measure the degree to which a community could potentially be impacted by an event, i.e. sensitivity, and its ability to cope with said impacts, i.e. adaptive capacity. Selected indicators such as poverty status and language isolation act as proxies to grasping the complex ways in which the social environment can be impacted by natural events, and provide an initial approach for discerning the critical social indicators that may be associated with greater relative impact and longer recovery times.

The selection of a small suite of sensitivity and adaptive capacity indicators – three for sensitivity and four for adaptive capacity – allows for each indicator to play a significant weighting role in determining the final ranking of sensitivity and adaptive capacity for each census tract. For example, the relatively lower presence of elderly aged over 65 in the North Cambridge neighborhood tips its final sensitivity scoring toward 2. As North Cambridge houses several lower-incomes and section 8 housing communities, it is considered a socioeconomically more vulnerable area compared to other parts of Cambridge, which may seem inadequately captured when considering the final sensitivity map of Cambridge. This ‘effect’ is mediated by the adaptive capacity ranking area, which shows pockets of North Cambridge, Neighborhood Nine, and other areas in the Eastern part of the City have the lowest relative adaptive capacity. This underscores the need for thoughtful selection of appropriate and descriptive social

indicators as they can color how Cambridge is ultimately represented. (See attachment for detailed methodology protocol)

Vulnerability Assessment

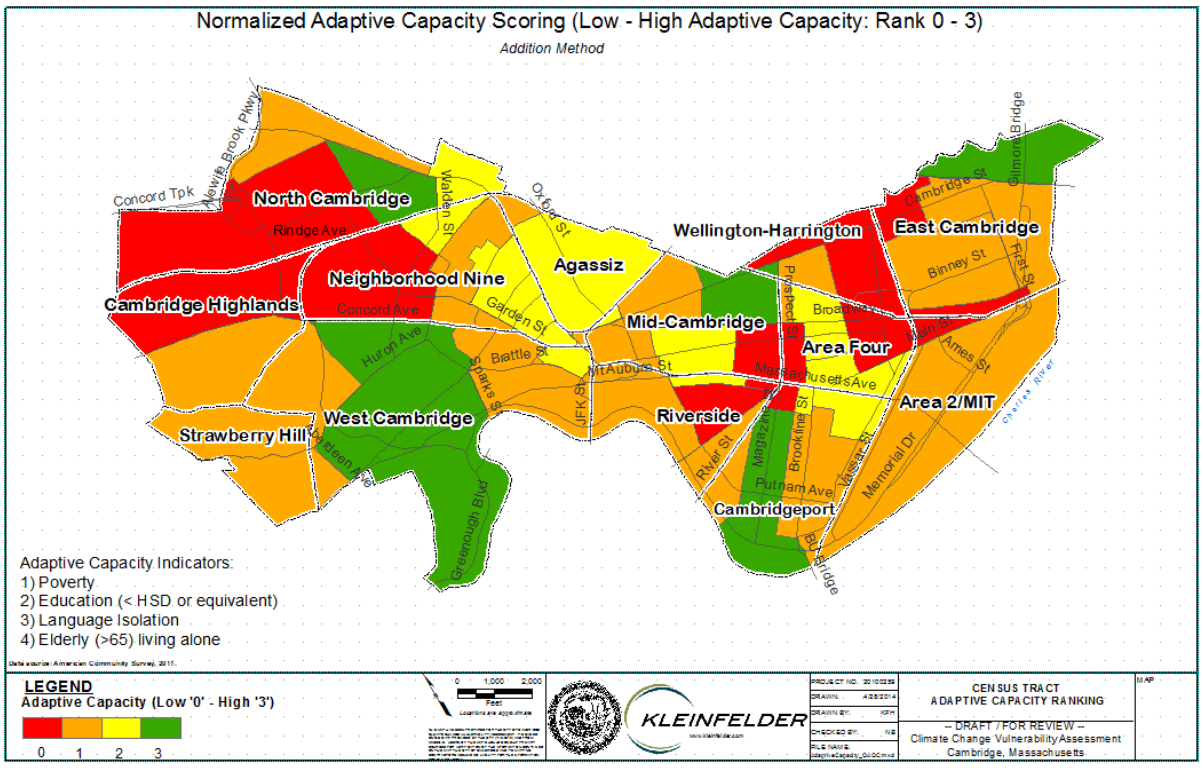
Each census tract has been assigned a vulnerability score drawing from its sensitivity and adaptive capacity based on social indicators. The analysis includes three social indicators of enhanced sensitivity to climate exposures: poverty, older than 65, and younger than 5. All three are thought to predispose individuals to greater risk from exposure to a given level of climate hazard exposure. On the occasion that a census tract receives a sensitivity score that is higher or lower than anticipated based on set indicators, the pairing with its adaptive capacity score has shown to mediate the final outcome. This is particularly the case in areas that may be home to a significant elderly population, or to young families, but where higher education, and earnings help to paint a very different pictures of social conditions.



Map 1: Census Tract Sensitivity Ranking (Source: Kleinfelder, May 2015**)**

Regarding adaptive capacity, four social indicators were selected to indicate for low capacity: poverty, low education level, language isolation, and elderly living alone. Note that sensitivity and adaptive capacity are both influenced to some extent by the same social factors, and this is taken into account in our choice of indicators.

Overall, the neighborhoods that emerge with the greatest sensitivity and adaptive capacity validate commonly held assumptions about where lower income, and other disadvantaged communities currently reside in the City. Observations based on the collective findings from both the sensitivity and adaptive capacity ranking indicate that parts of Area Four, Wellington-Harrington, and Riverside are particularly vulnerable. Pockets of North Cambridge, Cambridge Highlands and Neighborhood Nine would also emerge as vulnerable given their relatively lower adaptive capacity paired with a moderate sensitivity scoring.



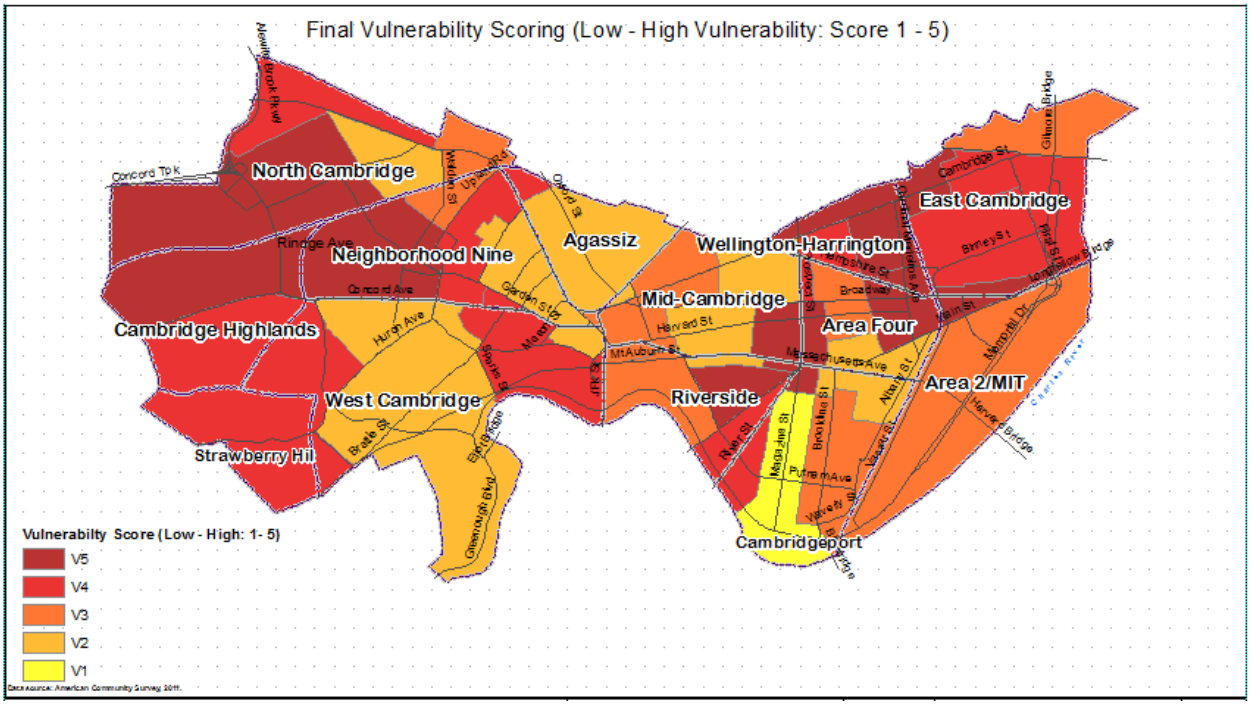
Map 2: Census Tract Adaptive Capacity Ranking (Source: Kleinfelder, May 2015)

The final step to complete the vulnerability scoring is based on the ICLEI-based vulnerability scoring matrix below. This matrix has been adopted and adapted for use in our vulnerability assessments of physical critical infrastructure.

		Sensitivity: Low → High			
		S1	**S2**	**S3**	**S4**
Adaptive Capacity: Low ↓ High	**AC0**	**V3**	**V4**	**V5**	**V5**
	AC1	**V2**	**V3**	**V4**	**V5**
	AC2	**V1**	**V2**	**V3**	**V4**
	AC3	**V1**	**V1**	**V2**	**V3**

Figure 1: Adapted ICLEI Vulnerability Assessment Matrix (source: Kleinfelder adapted from ICLEI))

The scoring chart above does not assume a one-to-one relationship between different forms of adaptive capacity and sensitivity. It cannot be assumed that a score of AC3 paired with a S3 would create a compensatory 'effect'. Therefore, at high levels of sensitivity, a minimum score of V1 is always used to accommodate for the possibility that the types of adaptive capacity available to a community may not help to mitigate the specific ways they are impacted by an event.



Map 3: Final Vulnerability Scoring Map (Source: Kleinfelder, May 2015)

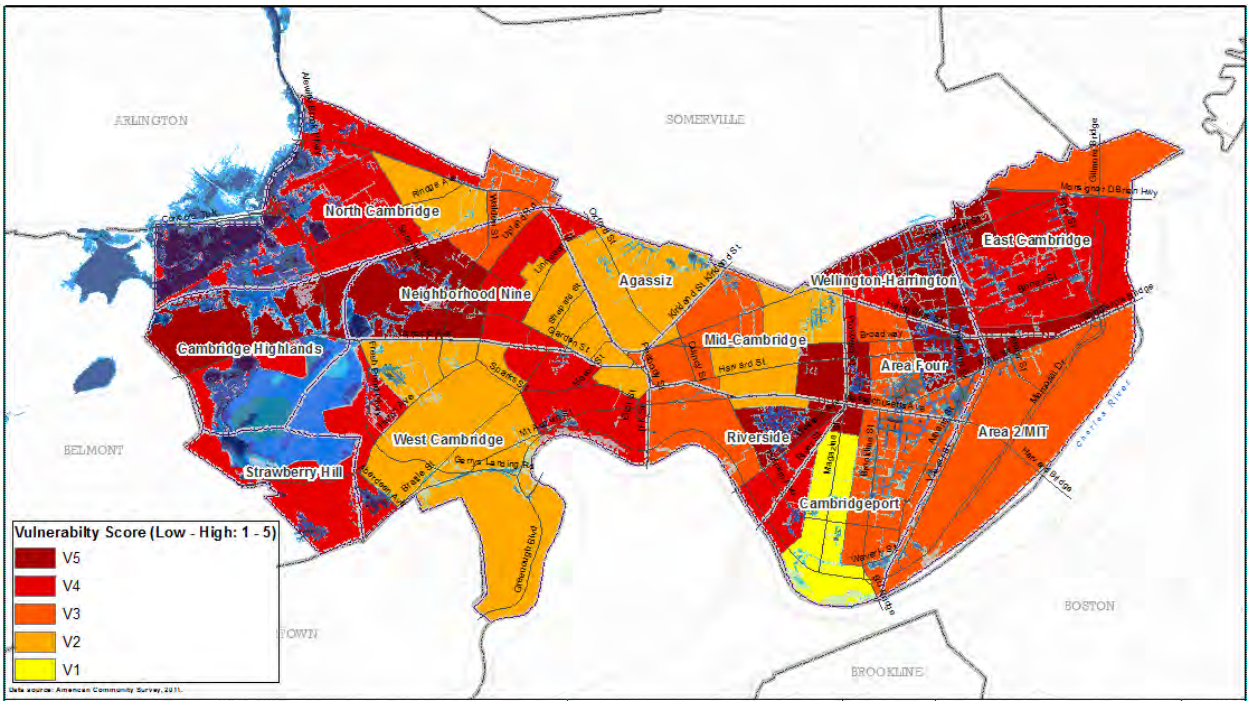
Key Findings

The Western half of Cambridge, along with significant areas in East Cambridge and Riverside indicate the highest vulnerability (V4 and V5) scores. As illustrated in the sensitivity and adaptive capacity scoring maps, this methodology based on social indicators of sensitivity and adaptive capacity push the census tracts comprising North Cambridge, Cambridge Highlands, Strawberry Hill, and Neighborhood Nine up toward the V4 –V5 range. This approach to measuring social vulnerability aligns with our initial perceptions of the City because it is based on the understanding that certain social factors such as educational status and age have implications for vulnerability.

Vulnerability to high heat exposure is assessed at a City-wide level consequently, the specific exposure to variation to heat islands per census tracts is not being reported as social vulnerability as reported above , and not heat islands, are the determinants for assessing vulnerability and high priority areas. .

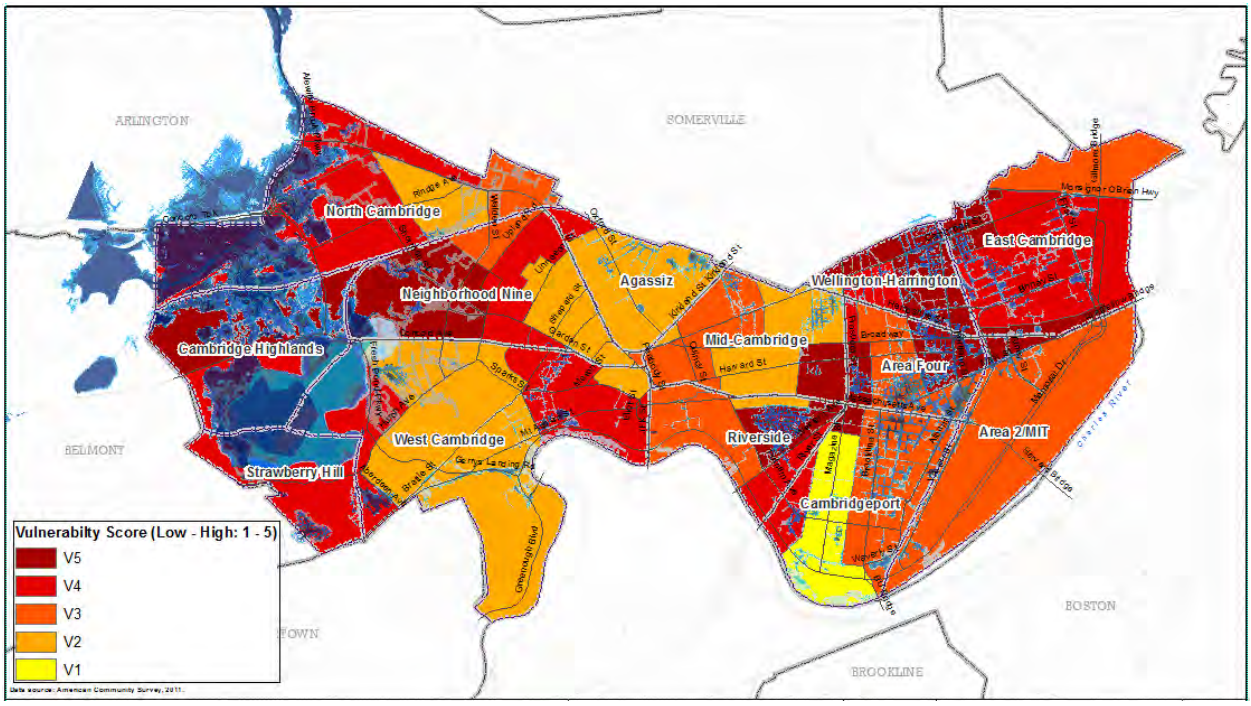
Flood exposure from the 2030 and 2070 ‘high’ scenarios was overlaid on top of the social vulnerability index results. The 2030 high scenario models 10.2 inches of precipitation within a

24-hour period, and the 2070 higher scenario models a rainfall event of 11.7 inches within a 24-hour period. This simple mapping exercise presents another lens through which to consider a combination of social vulnerability factors (sensitivity and adaptive capacity), as it intersects with flooding exposure.



Map 4: Results of 2030 High Scenario Flood Exposure overlaying map of social vulnerability
(Source: Kleinfelder, May 2015)

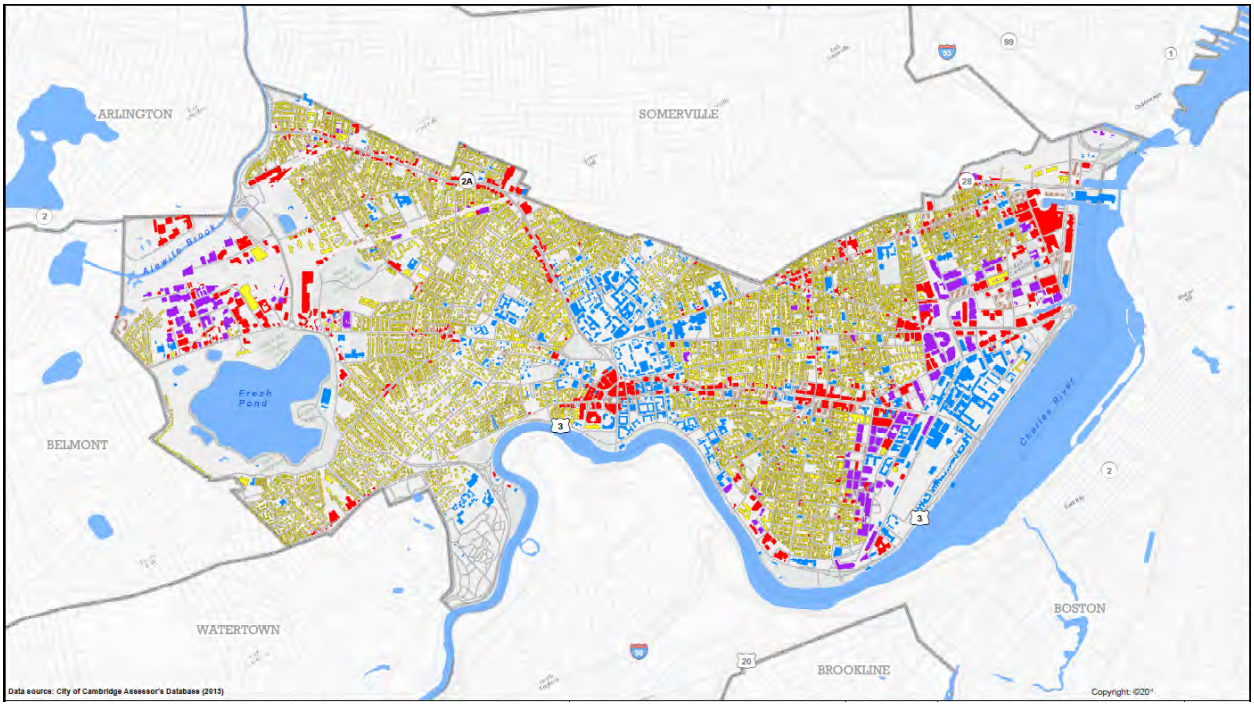
The 2030 and 2070 model results of precipitation-based flooding indicate severe flooding on the Alewife side of Cambridge, impacting Strawberry Hill, North Cambridge, Cambridge Highland neighborhoods. The model also indicates widespread flooding specifically in the Riverside and East Cambridge neighborhoods as well.



Map 5: Results of 2070 High Scenario Flood Exposure overlaying map of social vulnerability
(Source: Kleinfelder, May 2015)

The degree and extent of impact under the 2070 High Scenario exhibits the same spatial variability in flooding. The North Cambridge, Cambridge Highlands and Strawberry Hill neighborhoods are significantly impacted by flooding, with Riverside, East Cambridge, and parts of Area Four and Cambridgeport experiencing relatively more widespread flooding.

As a proxy/ placeholder for understanding buildings at risk, next steps should include a qualitative evaluation vulnerability related to potential indoor mold growth following flooding. We will draw knowledge from prior flooding events and the likelihood of flooding by neighborhood, based on climate projections and scenario development for the Cambridge project.



Map 6. Cambridge Buildings with Basements by Building Use. (Source: City of Cambridge as informed by 2013 Assessors data

Current limitation is in missing information in the current database. According to the Assessor's data base, buildings are identified as having a basement but does not document whether these are 'finished' or converted basements used as living space. Therefore, while it is possible to map buildings with basements, which may be most vulnerable to molds in the eventuality of flooding, it does not indicate basements that are inhabited by resident-owners or renters of the building. Of concern are residential buildings with basement units. For the purpose of this study, buildings with reported basement in the assessor's database have been allocated the permitted zoning land-use and vulnerability will be assessed accorded to allowed use as a proxy.

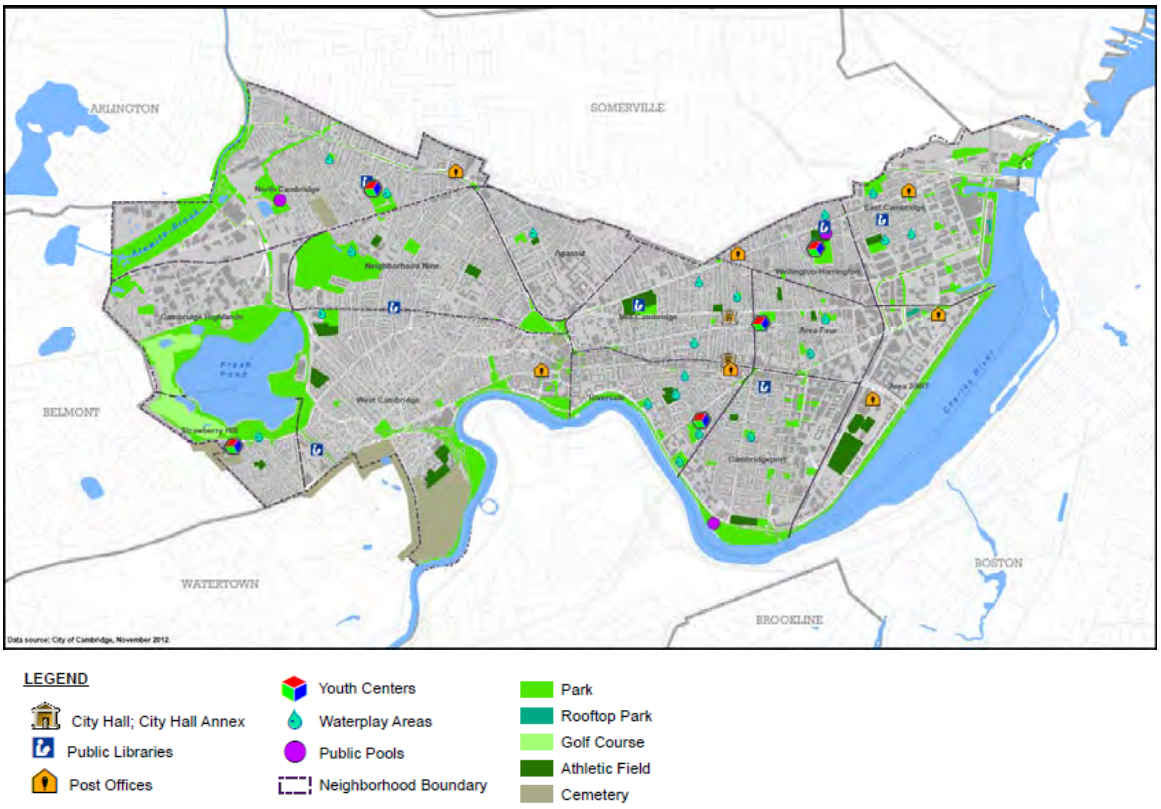
Under both the 2030 and 2070 high scenarios, the distribution of flood exposure relative to the social vulnerability index results shows a coincidence of more vulnerable neighborhoods (as determined by select social vulnerability factors), with greater exposure to flooding. These maps present a useful tool in considering the possible impacts from flooding on the neighborhood. The relative distribution of social vulnerability and exposure to climate change impacts has the

potential to be a planning tool for the City in determining 'vulnerable hotspots' in developing an emergency plan.

Next steps

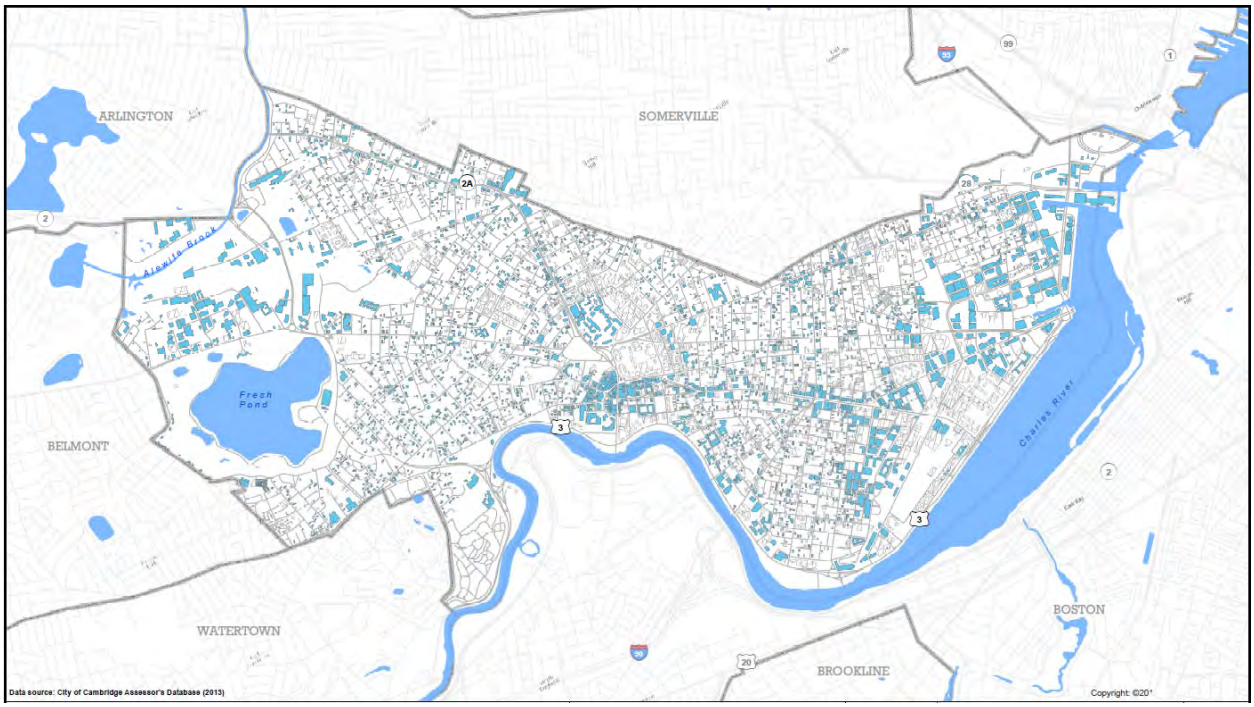
The next step will be in the integration of community and municipal resources in assessing vulnerability. These should include access to community resources, penetration of central air Conditioning (AC) and, access to supportive networks.

1. ***Community resources*** available to Cambridge residents to help support and cope with the impacts of flooding and heat afford some limited form of adaptive capacity. Pools, water play areas and parks play varying roles in ameliorating high heat conditions by mitigating the heat island effect, and may provide relief to certain sections of the population who are more likely to access these resources during a heat event. While these facilities cannot replace public health strategies for most vulnerable population they can contribute to define a 'new normal" for a warmer Cambridge.



Map 7: Municipal resources (Source: Produced by Kleinfelder, 2014)

2. ***Penetration of central AC:*** Also, as a preliminary indication of means to adapt or mitigate extreme heat, central air-conditioning (AC) ownership has been mapped using assessors data. This information will have to be studied in relation to vulnerable population to be able to assess sensitivity and adaptive capacity of vulnerable population.

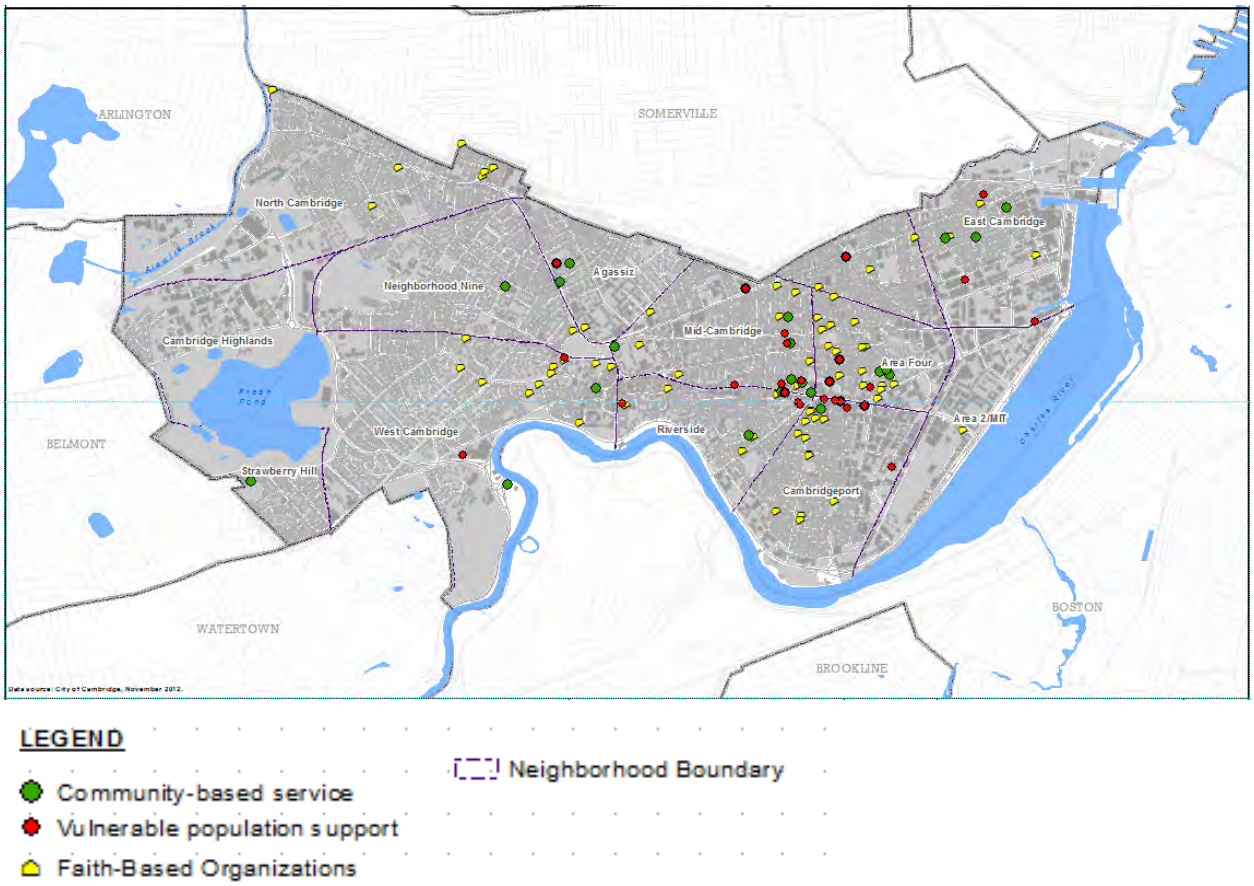


Central Air Conditioning by Building
Unknown
Yes

Map 8: Access to Central Air Conditioning per Census Tracts. **.** (Source: City of Cambridge as informed by 2013 Assessors data

3. ***Supportive network***: Finally, it should be reported that Cambridge is home to a diverse array of places of worship and other faith-based organizations. These are a critical supportive network for residents and families for whom these organizations are not only places of worship but opportunities to connect with other families in the same religious and often linguistic community. The concentration of faith-based organizations is evident in Area Four as well as towards the center of the City, between West Cambridge, Agassiz and

Neighborhood Nine. The communities that form around faith-based organizations, and other types of community-based organizations, are often based on other cultural, linguistic, and immigration-based bonds. These forms of community relationships and linkages can be only elucidated with community participation and further research but they provide an indication of resiliency.



Map 9. Community-Based Organizations and Services (Source: Produced by Kleinfelder, 2014 Using information provided by the City of Cambridge**)**

Demographic Changes and Environmental Justice

Projected Demographic Changes

Based on these projections, the City of Cambridge anticipates the population to increase by over 12% under the stronger region scenario. Increased population diversity, particularly under the Stronger Region scenario resulting from higher in-migration rates, and an increase in aging population is anticipated to be similar between the Status Quo and Stronger Region scenarios.

At present, population below age of 5 or above 65 represents about 13% of the total population. As projected in 2030s, these two age groups combined represent about 17% of the population therefore changing the profile of the City's demographics; this has implications for how the City may best address public health issues as they relate to certain types of climate change events. For example, the afore-mentioned population groups are particularly sensitive to heat waves.

Environmental Justice and Climate Change

The environmental justice (EJ) movement speaks to the activism in the early 1980s surrounding the siting of environmental hazards near populations of color. Drawn from those experiences and ongoing research, the environmental justice theoretical orientation informs discussion on how socially vulnerable communities may be disproportionately exposed to environmental hazards that recently have come to include exposure to certain types of climate change hazards. Expanding from the original discourse focused on race, the evolving EJ theoretical orientation also notes other social characteristics that may contribute to social vulnerability range from age to educational status. While exploring the potential environmental justice implications in the City of Cambridge is not within the scope of this study, our initial findings from the social vulnerability ranking methodology can help to inform future research. A range of socioeconomic and demographic characteristics have been incorporated as proxies for considering the adaptive capacity and sensitivity of Cambridge communities. These characteristics dovetail with research conducted in other contexts exploring the possible connections between social vulnerability, climate hazard exposure, and post-disaster recovery experiences.

As a preliminary qualitative analysis in comparing data reported by the City, it would appear that areas in north Cambridge and within the Area Four and Riverside are the most vulnerable population as reported on Map 3 of this report and also areas with higher proportion of Hispanic and black population.

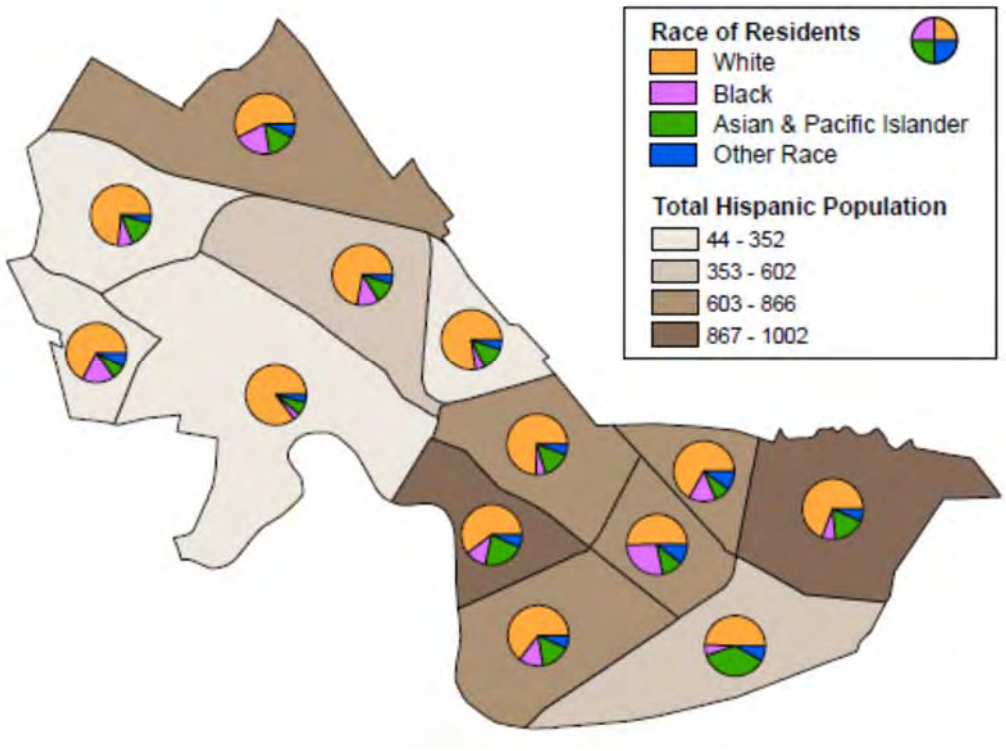
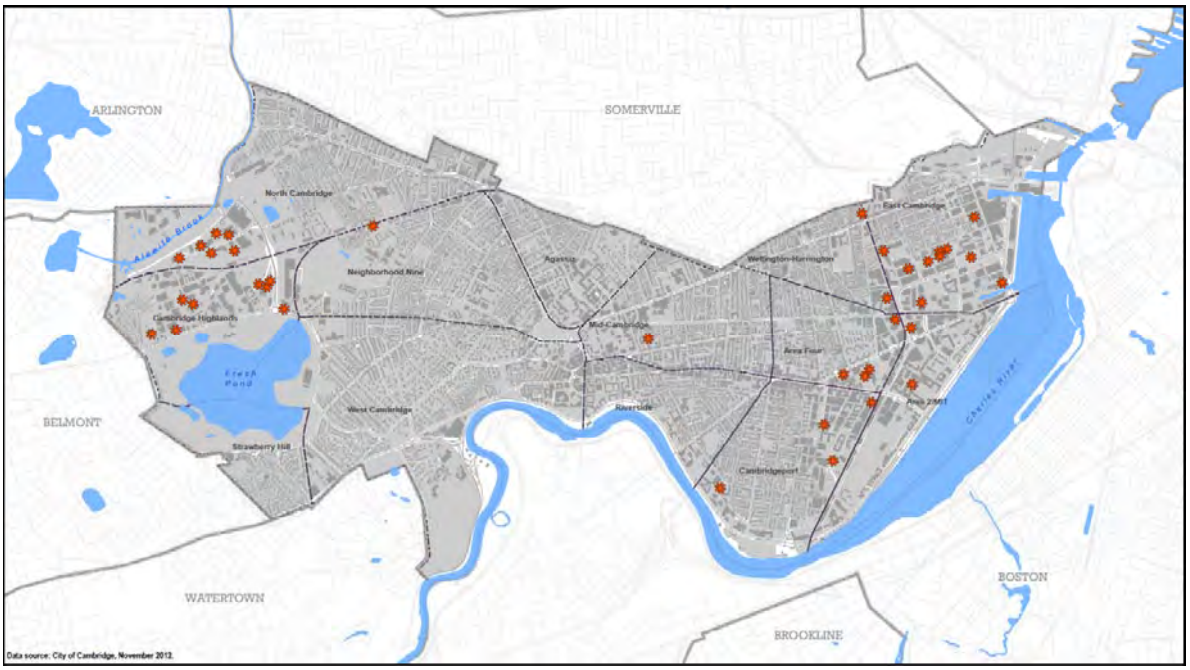


Figure 2. . 2010 Race and Hispanic Population (Source: 2010 Decennial census[2])

The map below locates the hazardous sites throughout the City as provided by the City of Cambridge. Information on the location of these sites is shared with the local emergency planning commission and Cambridge Fire Department. The reporting requirements set within the industry at the federal level and by the City of Cambridge enable the mapping of these hazardous material sites.

[2] *http://www.cambridgema.gov/~/media/Files/CDD/FactsandMaps/PopulationData/Maps/2010neigh/map_census_2010_neigh_race_hp.ashx*



LEGEND
Hazardous Materials Site Neighborhood Boundary

Map 10: Hazardous Material Sites (Source: Produced by Kleinfelder, 2014 Using information provided by the City of Cambridge)

It is important to note that most hazardous material sites are located within proximity of vulnerable groups as identified on the basis of the social vulnerability ranking methodology. These hazardous sites are co-located alongside the Eastern and Western parts of Cambridge where flood exposure under the 2030 and 2070 modeled scenarios is also the most significant. Coupled with relative higher flood exposure (see maps 4 and 5 of this document), and the distribution of hazard material sites, this observation presents implications for emergency management and planning especially for Cambridge residents living in proximity.. This further supports that more study is required on this front.

ATTACHMENT 1: Social Vulnerability Index and Ranking Protocol

MEMORANDUM

DATE: December 10th 2014 – Revised January 27, 2015

TO: John Bolduc, PM, City of Cambridge;
Sam Lipson, Environmental Health Director, Public Health Department

FROM: Lisa Dickson, Kleinfelder;
Nathalie Beauvais, Kleinfelder
Vijaylaxsmi Kesavan, Kleinfelder

CC: Patrick Kinney**,** Columbia University – Public Health

SUBJECT: Social Vulnerability Index and Ranking Protocol

KLEINFELDER NO.: 2010259.01-A

Overview

A social vulnerability ranking and mapping protocol was developed to assess the community-based vulnerability of Cambridge. This protocol adapts the ICLEI[1] vulnerability framework that was used to assess the vulnerability of the Cambridge built environment to heat waves and precipitation-based flooding. The ICLEI framework was adapted to address and measure social vulnerability while maintaining the component characteristics of vulnerability assessment- exposure, sensitivity and adaptive capacity.

Social indicators of sensitivity and adaptive capacity were uniquely derived from Cambridge-specific demographic and place-based indicators that represent the sensitivity and adaptive capacity of the social environment and its related physical assets. Most importantly, these indicators link directly with Cambridge geography by way of spatially relatable information drawn from multiple data sources including five-year American Community Survey, 2011 (2005 – 2010) data and assessor's parcel data. These data

[1] International Council for Local Environmental Initiatives – Local Governments for Sustainability

sources were used as proxies for the Cambridge demographic landscape and used to produce measurable sensitivity and adaptive capacity indicators such as degree of air conditioning penetration. Finally, spatial and statistical analysis techniques were employed to rank and map community-based sensitivity and adaptive capacity in terms of precipitation and heat exposure.

The vulnerability of the social environment is assessed in two parts – vulnerable populations, and physical assets that are deemed critical to the support of vulnerable populations. The latter includes a broad variety of community based organizations and facilities. Therefore, vulnerable populations are also integrated in the analysis of physical assets where most vulnerable populations are housed or receive services. These physical assets include -

- Affordable housing
- Homeless shelters
- Senior housing
- Schools

A. Indicator selection for Sensitivity and Adaptive Capacity

Social Indicators

Social indicators of sensitivity and adaptive capacity (Table 1) were informed by current literature on heat vulnerability (Kinney et al), and general environmental justice discourse on the human determinants of sensitivity and adaptive capacity (Kelly, Adger). The analysis includes three social indicators of enhanced sensitivity to climate exposures:

poverty, old age, and young age. All three are thought to predispose individuals to greater risk from exposure to a given level of climate hazard exposure. Regarding adaptive capacity, four social indicators were selected to report for low capacity: poverty, low education level, language isolation, and elderly living alone. Note that sensitivity and adaptive capacity are both influenced to some extent by the same social factors, and this is taken into account in our choice of indicators. These indicators are generated from census data acquired from the ACS 2011 Survey, and mapped at the census tract level for the 32 tracts in Cambridge.

Social Indicators:

Sensitivity	Adaptive Capacity
Poverty (as a proxy for health)	Poverty
Elderly (Above 65 years)	Education (HSD or equivalent)
Children (Below 5 years)	Language Isolation
	Elderly living alone

Table 1: Sensitivity and Adaptive Capacity Indicators

Information on disabilities and chronic illness is not collected by the Census or the City, and therefore not available to support the reporting of this vulnerable segment of the population. Therefore, these will be addressed qualitatively in the protocol.

B.Sensitivity and Adaptive Capacity Ranking:

Census tract-based statistics form the basis for assessing the sensitivity and adaptive capacity of the Cambridge social environment. The city of Cambridge has 32 census

tracts and a sample dataset is provided in table 4 below to illustrate how a 32 census-tract dataset is compiled per indicator for Cambridge.

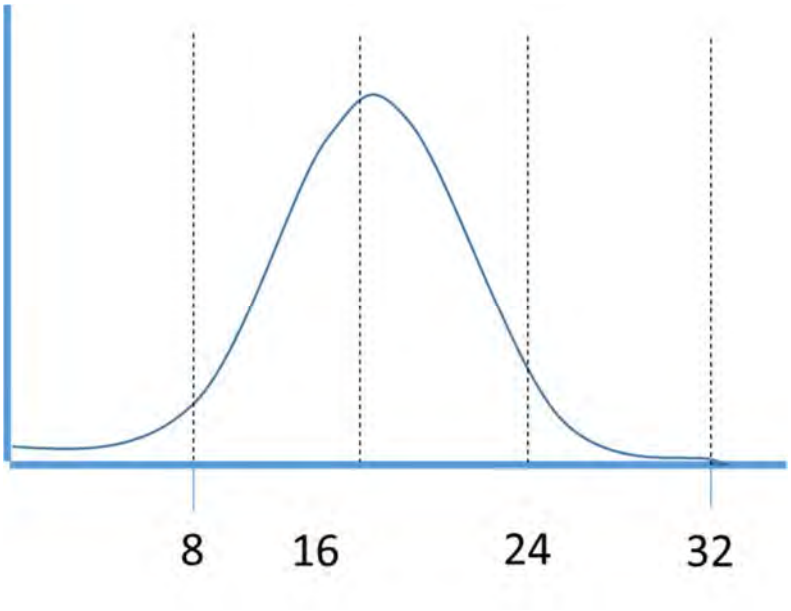


Figure 1: The Quartile approach: "tails" (25% lower and upper quadrants) start at ranks of 8 and 24, respectively (note: ideally the bell curve should be drawn so it has equal area in each of the four quartiles.)

Using the quartile ranking method distributes values equally within 25% intervals of a dataset - 0 – 25%, 26 – 50%, 51 – 75% and 76 – 100%. The census tracts falling into each quartile are assigned a rank from 1 to 4, and a corresponding sensitivity or adaptive capacity score (i.e.: a score of 1 is assigned to the first bucket of 1 – 25%, 2 for 25% - 50%). A score of S1 indicates that a census tract has a relatively lower proportion of a sensitivity indicator compared to other census tracts.

MEMORANDUM

Quartile Approach	Buckets
S1	0 - 25%
S2	26% - 50%
S3	51% - 75%
S4	76% - 100%

Table 3: Sensitivity Scoring using Quartiles

The following indicators for sensitivity and adaptive capacity were derived from census data or the assessor's parcel database, allowing this information to be spatially related to a census tract. This spatial relationship permits the use of the quartile ranking method to sort census tract-based data and assign relative sensitivity and adaptive capacity scores.

Sensitivity Indicators:

1. Elderly above 65 years
2. Poverty
3. Children below 5 years

A census tract ranking in the upper-most quartiles indicates the lowest relative percentage of the sensitivity indicators. As the relative percentage of sensitivity indicators increases, sensitivity increases from low to high.

Low Adaptive Capacity Indicators:
For social indicators as outlined in Table 1:

1. Poverty
2. Low llevel of education (Did not obtained High School Diploma or equivalent)
3. Language isolation
4. Elderly living alone

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The lower-most quartile corresponds to the highest relative percentage of the four social indicators listed on page 7, and report the lack of adaptive capacity as a result of poverty, low educational attainment, etc. Consequently, the presence of one or more of these indicators corresponds to a reduced adaptive capacity.
For physical resources that provide adaptive capacity, place-based indicators are as outlined in Table 2 (see page 4).

Step 1: Sorting census tract data

Table 4 below illustrates the use of quartile ranking to sort census tracts by the sensitivity indicator 'Elderly above 65 years'. The right-most column identifies the sensitivity scoring for each tract. This approach will be repeated for all three sensitivity indicators so that each census tract has three unique sensitivity scores corresponding to each indicator.

MEMORANDUM

Tract	Pct Above 65 (sorted in ascending)	Rank	Sensitivity Score
Census Tract 3521.01	0	1	1
Census Tract 3531.01	2.3	2	1
Census Tract 3524	3	3	1
Census Tract 3523	3.1	4	1
Census Tract 3525	3.9	5	1
Census Tract 3528	4.1	6	1
Census Tract 3534	4.8	7	1
Census Tract 3538	5.4	8	2
Census Tract 3533	5.8	9	2
Census Tract 3529	5.9	10	2
Census Tract 3549	6.7	11	2
Census Tract 3548	6.8	12	2
Census Tract 3539	6.8	13	2
Census Tract 3532	7.1	14	2
Census Tract 3544	7.4	15	2
Census Tract 3536	7.9	16	3
Census Tract 3537	9.3	17	3
Census Tract 3547	9.6	18	3
Census Tract 3535	9.6	19	3
Census Tract 3531.02	10.1	20	3
Census Tract 3546	10.3	21	3
Census Tract 3540	11.2	22	3
Census Tract 3526	11.4	23	3
Census Tract 3542	12	24	3
Census Tract 3521.02	12.2	25	4
Census Tract 3530	12.4	26	4
Census Tract 3527	13.7	27	4
Census Tract 3545	14.1	28	4
Census Tract 3543	14.5	29	4
Census Tract 3550	17.5	30	4
Census Tract 3541	20.1	31	4
Census Tract 3522	21.9	32	4

Table 4: Sample dataset of sensitivity scoring - percentage of 65 years or older, sorted in ascending order and ranked.

Note: See map on page 13 for geographic location of each census

MEMORANDUM

Tract	Pct Below Poverty Line (sorted in descending)	Rank	Adaptive Capacity Score
Census Tract 3521.01	36.4%	1	0
Census Tract 3521.02	29.9%	2	0
Census Tract 3522	29.6%	3	0
Census Tract 3523	25.8%	4	0
Census Tract 3524	25.3%	5	0
Census Tract 3525	23.9%	6	0
Census Tract 3526	23.5%	7	0
Census Tract 3527	18.8%	8	0
Census Tract 3528	17.9%	9	1
Census Tract 3529	17.6%	10	1
Census Tract 3530	17.5%	11	1
Census Tract 3531.01	17.0%	12	1
Census Tract 3531.02	16.7%	13	1
Census Tract 3532	15.7%	14	1
Census Tract 3533	15.0%	15	1
Census Tract 3534	14.5%	16	1
Census Tract 3535	13.6%	17	2
Census Tract 3536	12.7%	18	2
Census Tract 3537	12.7%	19	2
Census Tract 3538	12.6%	20	2
Census Tract 3539	12.6%	21	2
Census Tract 3540	12.2%	22	2
Census Tract 3541	10.3%	23	2
Census Tract 3542	9.7%	24	2
Census Tract 3543	9.3%	25	3
Census Tract 3544	8.6%	26	3
Census Tract 3545	8.1%	27	3
Census Tract 3546	7.2%	28	3
Census Tract 3547	7.1%	29	3
Census Tract 3548	6.5%	30	3
Census Tract 3549	4.2%	31	3
Census Tract 3550	3.6%	32	3

Table 5: Sample dataset of adaptive capacity scoring - percentage below poverty status, sorted in descending order and ranked.

Note: See map on page 13 for geographic location of each census tract.

MEMORANDUM

Step 2: Calculating Sensitivity and Adaptive Capacity scores per census tract

Overall sensitivity and adaptive capacity scores will be calculated from the individual scores resulting from each ranking.

The sensitivity scoring scale will range from 1 – 4, and assigned accordingly:

Rank of 1 -7 –	Sensitivity Score = 1	**LOW**
Rank of 8-15 –	Sensitivity Score = 2	↓
Rank of 16-24 –	Sensitivity Score = 3	
Rank of 25-32 –	Sensitivity Score = 4	**HIGH**

The adaptive capacity scoring scale will also be a four-point scale; please note the ranks per quartile are reversed to align with low adaptive capacity, which is the most greatly reduced in the upper-most quartile. The higher ranks therefore report the greatest presence of social indicators corresponding to a low adaptive capacity (see page 8), and is scaled accordingly:

Rank of 25-32 –	Adaptive Capacity Score = 0	**LOW**
Rank of 16-24–	Adaptive Capacity Score = 1	↓
Rank of 8-15 –	Adaptive Capacity Score = 2	
Rank of 1 -7 –	Adaptive Capacity Score = 3	**HIGH**

Step 3: Calculating total sensitivity and adaptive capacity scores

MEMORANDUM

The overall sensitivity of a census tract will be determined from adding the sensitivity scores to produce a total sensitivity score, as below:

Sensitivity Score (SS) for elderly x SS for poverty x SS for children

Ex: 1 + 4 + 4 = 9

The second step will be to normalize these scores on a 100 point scale:

To normalize = 16/64* 100 = 25

Total Sensitivity Score = **25**

This approach will be adjusted as needed once the various indicators have ranked by census tract to determine the best approach for deriving sensitivity and adaptive capacity scores. Alternatives include adding the intermediate scores instead of multiplying them.

Step 4: Aligning with ICLEI scores

A sensitivity and adaptive capacity score ranging from 1 – 4 or 0 – 3 respectively will be assigned to each census tract in order to align with the ICLEI vulnerability framework. The original ICLEI vulnerability framework was adapted to fit the quantile-based four point scale developed to score and rank the vulnerability of census tract. As a result, the original five-point scoring of sensitivity and adaptive capacity is reduced to a four-point chart, illustrated in figure 2. The total sensitivity and adaptive capacity scores calculated in Step 3 will be fitted to the original ICLEI scoring scales by first observing the overall range of scores produced and assigning a relative value based on its distribution in the range.

MEMORANDUM

		Sensitivity: Low → High			
		S1	S2	S3	S4
Adaptive Capacity: Low ↓ High	AC0	V3	V4	V5	V5
	AC1	V2	V3	V4	V5
	AC2	V1	V2	V3	V4
	AC3	V1	V1	V2	V3

Figure 2: Adapted ICLEI Vulnerability Assessment Matrix

C. High Risk Priority Areas

Once the most vulnerable areas are identified by way of census tracts, this information will be shared with City stakeholders and reviewed to evaluate if specific community or ethnic groups are disproportionately impacted by climate change. If determined to be a relevant, will be considered carefully as part of the preparedness phase of the project.

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The Western half of Cambridge, along with significant areas in East Cambridge and Riverside indicate the highest vulnerability (V4 and V5) scores. As anticipated from the sensitivity and adaptive capacity scoring maps, this methodology based on social indicators of sensitivity and adaptive capacity push the census tracts comprising North

MEMORANDUM

Cambridge, Cambridge Highlands, Strawberry Hill, and Neighborhood Nine up toward the V4 –V5 range. This approach to measuring social vulnerability aligns with our initial perceptions of the City because it is based on the understanding that certain social factors such as educational status and age, have implications for vulnerability.

MEMORANDUM

MAP LOCATING CENSUS TRACT NUMBERS