

ND-GAIN’s Pilot Urban Adaptation Assessment Technical Document

Table of Contents

ND-GAIN’S URBAN ADAPTATION ASSESSMENT COMPONENTS	3
COMPONENT DEFINITIONS.....	3
INDICATOR INFORMATION (63 TOTAL)	4
LIVES AND LIVELIHOODS (2 TOTAL).....	4
1. Lives outcome variable	4
2. Livelihoods outcome variable.....	4
VULNERABILITY (27 TOTAL)	5
<i>Hazards (3 total).....</i>	<i>5</i>
3. Flooding.....	5
4. Extreme heat.....	5
5. Extreme cold.....	5
<i>Sensitivity (14 total).....</i>	<i>6</i>
6. Percent of the population living or residing in informal settlements.....	6
7. Average age of buildings.....	6
8. Quality of drinking water	6
9. Percent of bridges in the city at risk to floods	6
10. Percent of total length of roads at risk to floods.....	7
11. Percent of the population under 18 years old	7
12. Percent of the population that is 75 years old and over	7
13. Percent of the population with poor or fair health conditions.....	7
14. Percent of uninsured population	8
15. Level of electricity consumption per customer.....	8
16. Percent of housing units with air conditioning	8
17. Percent of housing with heating fuel available	9
18. Percent of housing units with heating equipment that reported heating problems	9
19. Average price of megawatt hour in cents for electricity	9
<i>Adaptive Capacity (10 total).....</i>	<i>9</i>
20. Frequency of public transport use	9
21. Volume of water that treatment plant processes in 24 hours	10
22. Percent of area that is impervious surface.....	10
23. Percent land covered by tree canopy	10
24. Percent of adults over the age of 65 that report having influenza in the past 12 months	10
25. Percent of adults who needed to see a doctor but could not because of cost.....	11
26. Rate among Medicare beneficiaries of inpatient or hospital outpatient emergency department visits.....	11
27. Percent of Medicare beneficiaries eligible for Medicaid.....	11
28. Number of acute care hospital beds per 1,000 residents.....	12
29. Access to warming center when the temperature falls below 32 degree.....	12
READINESS (34 TOTAL).....	12
<i>Economic (12 total).....</i>	<i>12</i>
30. Gross production per capita.....	12
31. Percent of population in poverty.....	13
32. Dependence on internal cash flow versus imported cash flow.....	13
33. State minimum wage	13
34. Household average income.....	14
35. City government deficit/surplus ratio.....	14
36. Percent civilian unemployment.....	15
37. Median house value	15
38. Percent of households receiving Social Security	15
39. Percent of females between age 20 and 64 that are in the labor force	16

ND-GAIN’s Pilot Urban Adaptation Assessment Technical Document

40. Percent of employed population 16 years and older employed in service occupation	16
41. Gini coefficient of household income inequality	16
<i>Governance (8 total)</i>	<i>17</i>
42. The degree of government's dedication to climate change adaptation.....	17
43. Transparency and accountability in governance	17
44. Total number of police officers per 10,000 residents	17
45. Civic engagement	17
46. Total number of federal public corruption convictions.....	18
47. Tax incentives for adaptation investment	18
48. Existence of a city wide siren alert system.....	18
49. Existence of city wide warning systems	18
<i>Social (14 total).....</i>	<i>19</i>
50. General innovation capabilities.....	19
51. Estimated percent of adults who think global warming is already harming people in the US now or within 10 years	19
52. Estimated percent of adults who think global warming will harm people in the US.....	19
53. Percent of population speaking only majority language.....	19
54. Percent of a population speaking the majority language at least very well.....	20
55. Existence of neighborhood watch program.....	20
56. Existence of community centers.....	20
57. Percent of the population with less than 12 th grade education.....	21
58. Percent of workers 16 years and older with no vehicle.....	21
59. Number of reported property crime offenses per 100,000 of the population	21
60. Percent of total students eligible to participate in the National School Lunch Program under the Free Lunch Act	21
61. Percent of buildings that are LEED approved.....	22
62. Percent of total population with Food Stamp/SNAP benefits in the past 12 months.....	22
63. Existence of energy cost saving programs for the poor	22
WORKS CITED.....	23

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

ND-GAIN's Urban Adaptation Assessment Components

Based on Advisor feedback and identified gaps in both literature and practice, the ND-GAIN Urban Adaptation Assessment includes:

- a climate hazard-based approach to vulnerability;
- a readiness component capturing the non-climatic characteristics that effect adaptability;
- an overall focus on impact to urban lives and livelihoods.

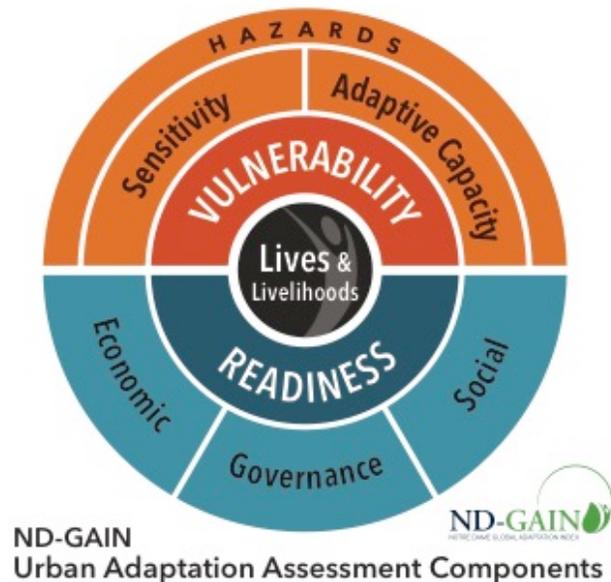


Figure 1: ND-GAIN's Urban Adaptation Assessment Components

Component Definitions

- **Lives and livelihoods:** The impact of specific climate hazards on a city, to be specific, on lives (impacted population from climate disasters, measured by *summation of injured population per capita and per occurrence and death toll per capita and per occurrence of climate disasters*), and on livelihoods (property damages, measured by *property damage per capita and per occurrence of climate disasters*).
- **Vulnerability:** The degree to which an urban area is unable to cope with the impacts of three primary climate hazards (extreme cold, flooding, and extreme heat) on its human population. Vulnerability is a function of the *hazard*, a city's *sensitivity* to the hazard, and its *adaptive capacity*.
 - **Hazard:** The potential occurrence of a biophysical event, trend or impact caused by climate change. In UAA, hazard indicators are quantified by the projection of the hazard magnitude between 1950-1999 (as historical baseline) and between 2020-2049 (as future projections)
 - **Extreme cold hazard:** measured by the annual count of days with at least 6 consecutive days when the daily maximum temperature is lower than the 10th percentile of the maximum temperature in the base period
 - **Flooding hazard:** measured by the annual maximum consecutive 5-day precipitation

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

- **Extreme heat hazard:** Annual count of days with at least 6 consecutive days when the daily maximum temperature is higher than the 90th percentile of the maximum temperature in the base period
 - **Sensitivity:** The extent to which an urban area will be affected by, or responsive to, a climate hazard. In UAA, sensitivity indicators measure the features of an urban area that amplify the impacts to the climate hazard, e.g. the proportion of buildings at risk of flooding.
 - **Adaptive Capacity:** The ability of an urban area to prepare for or cope with the climate hazard. In UAA, adaptive capacity measures to what extent an urban area is capable of minimizing the impacts of climate hazard, e.g. the number of medical facilities. It is also known as climate adaptive capacity.
 - **Readiness:** The general features of urban areas that will enable policy change and action implementation to reduce vulnerability to climate hazards. In UAA, readiness is composed of the measure of *economic conditions*, *governance support*, and *social capacities*. It is also known as generic adaptive capacity.

Each of these components corresponds with a series of indicators, detailed below.

Indicator Information (63 total)

Lives and Livelihoods (2 total)

1. Lives outcome variable

Description: The impact on urban lives from climate hazards in terms of lives lost and lives injured

Rationale: The impact of climate hazards on urban lives can be measured several ways, but lives saved and injuries prevented are the desired outcomes for any urban area.

Calculation: Measured by the summation of injured population per capita and per hazard occurrence and death toll per capita and per hazard occurrence. Data were standardized by population and by the number of hazard occurrences.

Data Source: (SHELDUS, 2015)

Coverage: 5 cities.

Time Series: 1960 - Present

Notes:

2. Livelihoods outcome variable

Description: The impact on urban livelihoods from climate hazards in terms of property damage

Rationale: The impact of climate hazards on urban livelihoods can be measured several ways, but many stakeholders are concerned about the extent of property damage incurred. In addition, this indicator acts as a proxy for establishing overall impact to the city infrastructure (effecting transportation, access to work and school, etc.)

Calculation: Measured by property damage per capita and per hazard occurrence. Data were standardized by population and by the number of hazard occurrences.

Data Source: (SHELDUS, 2015)

Coverage: 5 cities.

Time Series: 1960 - Present

Notes:

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Vulnerability (27 total)

Hazards (3 total)

3. Flooding

Description: Annual maximum consecutive 5-day precipitation

Rationale: Cited as a primary climate hazard for urban areas (Hunt et al., 2011)

Calculation: This hazard is measured through the UAA hazard score, which measures a city's climate-hazard risk. The score describes the expected value of the appropriate climate-index magnitude, normalized by the historical average magnitude calculated across all five pilot cities. It is therefore a relative score: each city is compared to the historical all-city average

Data Source: For all three climate scenarios (i.e., the historical and the two future scenarios), ND-GAIN used data from the Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections archive (Climate Analytics Group, 2014; Maurer et al., 2010, 2002; Reclamation, 2013).

Coverage: 5 cities. National data downscaled for specific cities.

Time Series: Projection of hazard magnitude between 1950-1999 as historical baseline and between 2020-2049 as future projection.

Notes:

4. Extreme heat

Description: Annual count of days with at least six consecutive days when the daily maximum temperature is higher than the 90th percentile of the maximum temperature in the base period

Rationale: Cited as a primary hazard for urban areas (Hunt et al., 2011)

Calculation: This hazard is measured through the UAA hazard score, which measures a city's climate-hazard risk. The score describes the expected value of the appropriate climate-index magnitude, normalized by the historical average magnitude calculated across all five pilot cities. It is therefore a relative score: each city is compared to the historical all-city average

Data Source: For all three climate scenarios (i.e., the historical and the two future scenarios), ND-GAIN used data from the Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections archive (Climate Analytics Group, 2014; Maurer et al., 2010, 2002; Reclamation, 2013).

Coverage: 5 cities. National data downscaled for specific cities.

Time Series: Projection of hazard magnitude between 1950-1999 as historical baseline and between 2020-2049 as future projection.

Notes:

5. Extreme cold

Description: Annual count of days with at least six consecutive days when the daily maximum temperature is lower than the 10th percentile of the maximum temperature in the base period

Rationale: City advisors identified extreme cold to be an important climate hazard to consider.

Calculation: This hazard is measured through the UAA hazard score, which measures a city's climate-hazard risk. The score describes the expected value of the appropriate climate-index magnitude, normalized by the historical average magnitude calculated across all five pilot cities. It is therefore a relative score: each city is compared to the historical all-city average

Data Source: For all three climate scenarios (i.e., the historical and the two future scenarios), ND-GAIN used data from the Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections archive (Climate Analytics Group, 2014; Maurer et al., 2010, 2002; Reclamation, 2013).

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Coverage: 5 cities. National data downscaled for specific cities.

Time Series: Projection of hazard magnitude between 1950-1999 as historical baseline and between 2020-2049 as future projection.

Notes:

Sensitivity (14 total)

6. Percent of the population living or residing in informal settlements

Description: Informal settlements are manufactured or mobile homes and trailers. Based on the estimates by the American Community Survey, this indicator measured the percent of the population living or residing in informal settlements. (flood_mobilehome).

Rationale: Affordable housing, such as manufactured or mobile homes, have historically been vulnerable to multiple weather shocks, including flooding. Through better installation regulation, cities can improve the flooding resistance of this type of housing (FEMA, 2009).

Calculation: Percent of total population living on informal settlements.

Data Source: [American Community Survey](#).

Coverage: 4 cities. (National survey, multiple cities)

Time Series: 2010-2014

Notes: Flooding hazard indicator.

7. Average age of buildings

Description: The mean age for all occupied housing units (the amount of time that structure has stood). Unoccupied and non-residential units are not included in the average. (flood_building_age).

Rationale: Older structures are more vulnerable to disasters and shocks.

Calculation: Average of building ages

Data Source: [American Community Survey](#).

Coverage: 5 cities. National survey, multiple cities available.

Time Series: 2005-2014.

Notes: Flooding hazard indicator.

8. Quality of drinking water

Description: The quality is measured by coliform reading in the drinking water pipes. Coliform bacteria indicate disease-causing pathogens could be present in the drinking water. (water_quality).

Rationale: The general capacity of providing clean drinking water reflects overall capacity to effectively deal with emergencies that threat drinking water quality amid disruptive events, including flooding.

Calculation: N/A

Data Source: STAR Communities.

Coverage: 4 cities (missing Los Angeles).

Time Series: 2015.

Notes: Flooding hazard indicator.

9. Percent of bridges in the city at risk to floods

Description: The percent of bridges in the city that are at risk of experiencing flooding. (bridge).

Rationale: The more transport infrastructure, represented here by bridges, in the flood zones, the more a city is likely to be susceptible to a flooding hazard.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Calculation: The National Bridge Inventory dataset was used in this analysis. This dataset has location of bridges for continental USA. A python script was written to automate to count bridges within FEMA flood zones for each city. The flood zones were broken down into base flood hazard area, moderate hazard area and minimal hazard area.

Data Source: [US Department of Transportation](#).

Coverage: 5 cities. Nationwide data available.

Time Series: 2012.

Notes: Flooding hazard indicator.

10. Percent of total length of roads at risk to floods

Description: The percent of total length of roads that are at risk of experiencing flooding. (road).

Rationale: The more transport infrastructure, represented here by roads, in the flood zones, the more a city is likely to be susceptible to a flooding hazard.

Calculation: All primary and secondary roads including highways were considered. GIS data for each city were collected and intersected by different FEMA zones in each city. The flood zones were broken down into base flood hazard area and moderate hazard area.

Data Source: [Seattle](#), [Los Angeles](#), [Baltimore](#), [Davenport](#), [Memphis](#)

Coverage: 5 cities. Each city was researched individually.

Time Series: 2012.

Notes: Flooding hazard indicator.

11. Percent of the population under 18 years old

Description: The percent of the city that is youthful. Youthful populations are defined as those under the age of 18 years old. (flood_youth) (heat_youth).

Rationale: Younger individuals are a vulnerable population.

Calculation: N/A

Data Source: [American Community Survey](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2009-2014.

Notes: Flooding and extreme heat hazard indicator.

12. Percent of the population that is 75 years old and over

Description: The portion of the population that is elderly, or 75 years and older. (flood_elderly) (heat_elderly).

Rationale: The portion of the population in poor or fair health, especially the elderly, is particularly vulnerable. Improving overall health conditions helps to reduce the vulnerability to post-flooding health threats (CDC, 2012).

Calculation: N/A

Data Source: [American Community Survey](#).

Coverage: 5 cities. National survey, multiple cities available.

Time Series: 2009-2014.

Notes: Flooding and extreme heat hazard indicator.

13. Percent of the population with poor or fair health conditions

Description: The percent of adult individuals reporting fair or poor health, according to the County Health Rankings. (flood_poor_health) (heat_poor_health).

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Rationale: The portion of the population in poor or fair health, especially the elderly, is particularly vulnerable. Improving overall health conditions helps to reduce the vulnerability to post-flooding health threats (CDC, 2012).

Calculation: N/A

Data Source: [County Health Rankings](#).

Coverage: 5 counties. Nationwide data available.

Time Series: 2006-2012.

Notes: Flooding and extreme heat hazard indicator.

14. Percent of uninsured population

Description: The percent of population under age 65 without health insurance. (flood_uninsured) (heat_uninsured).

Rationale: When post-flooding diseases threaten lives and livelihoods, the low-income population that lacks health insurance will be largely affected. Providing or improving affordable health care helps address the vulnerability of this particular group, hence the overall vulnerability of a city.

Calculation: N/A

Data Source: [County Health Rankings](#).

Coverage: 5 counties. Nationwide data available.

Time Series: 2006-2012.

Notes: Flooding exposure and heat indicator.

15. Level of electricity consumption per customer

Description: The average level of energy consumption as measured by megawatt hours consumed per customer. (electricity_consumption).

Rationale: In the event of extreme heat / extreme cold hazards, residents rely on air conditioning / home heating for indoor cooling/heating. Electricity consumption aims to capture the pressure on a city's electricity infrastructure by those climate hazards.

Calculation: The total amount of sales, on megawatt hours, was divided by the number of customers.

Data Source: [US Energy Information Administration](#).

Coverage: 4 cities (missing Davenport). Nationwide data available.

Time Series: 2005 - 2014.

Notes: Extreme heat and extreme cold hazard indicator.

16. Percent of housing units with air conditioning

Description: The percent of housing units with an air conditioning system. The American Housing Survey performed the "Heating, Air Conditioning, and Appliances" survey on housing units for selected metropolitan areas. (home_cooling)

Rationale: In the event of extreme heat hazard, more residencies with access to air conditioning can increase the adaptability of a city.

Calculation: The number of housing units with a central air conditioning system was divided by the total number of housing units in the specified area.

Data Source: [US Census](#).

Coverage: 4 cities (missing Davenport). Selected Metropolitan Areas available.

Time Series: 2011 and 2013 (2011 for some cities and 2013 for other ones.)

Notes: Extreme heat hazard indicator

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

17. Percent of housing with heating fuel available

Description: The percent of housing units with heating fuel available for heating the home. (home_heating).

Rationale: In the event of extreme cold hazard, residents rely on home heating. Those without are especially vulnerable to the hazard.

Calculation: The amount of housing units with heating fuel was divided by the total amount of housing units.

Data Source: [US Census](#).

Coverage: 4 metropolitan areas (missing Davenport). Selected Metropolitan Areas.

Time Series: 2011 for Los Angeles and Memphis, 2013 for Seattle and Baltimore.

Notes: Extreme cold hazard indicator.

18. Percent of housing units with heating equipment that reported heating problems

Description: The percent of housing units with heating equipment that reported heating problems. Data is shown for housing units occupied by the householder during the winter prior to the interview and refer only to the main heating equipment. (cold_housing_problems).

Rationale: In the event of extreme cold hazard, residents rely on home heating. Those without or experiencing problems are especially vulnerable to the hazard.

Calculation: The amount of housing units with heating equipment that reported heating problem divided by the total amount of housing units.

Data Source: [US Census](#).

Coverage: 4 metropolitan areas (missing Davenport). Selected Metropolitan Areas available.

Time Series: 2011 for Los Angeles and Memphis, 2013 for Seattle and Baltimore.

Notes: Extreme cold hazard indicator.

19. Average price of megawatt hour in cents for electricity

Description: The average price of a megawatt hour in cents for electricity. (electricity_price).

Rationale: In the event of extreme heat / extreme cold hazards, residents may rely on air conditioning / home heating for indoor cooling / heating. Cost of electricity seeks to capture the accessibility of the electric energy.

Calculation: The total revenue, in dollars, was divided by the total amount of sales, in megawatt hours.

Data Source: [US Energy Information Administration](#).

Coverage: 4 cities (missing Davenport). Nationwide data available.

Time Series: 2005 - 2014.

Notes: Extreme cold and extreme heat hazard indicator.

Adaptive Capacity (10 total)

20. Frequency of public transport use

Description: The frequency at which public transportation is used, measured by the trips taken via public transit per capita. (trips_per_capita).

Rationale: FEMA considers evacuating the area the safest way to survive a flood (FEMA, 2014). Public transportation is particularly important for those that do not own private vehicles or do not have access to private transport. Improving the accessibility of public transport reduces the vulnerability of the disadvantaged group.

Calculation: N/A

Data Source: [National Transportation Database](#).

Coverage: 5 cities. Some cities available.

Time Series: 2013.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Notes: Flooding hazard indicator.

21. Volume of water that treatment plant processes in 24 hours

Description: The volume of water that treatment plants process in 24 hours. (flood_water_treatment).

Rationale: When the system exceeds its capacity due to excessive storm water, combined sewer systems may cause discharge of untreated wastewater directly to the surface. As a costly infrastructure retrofitting option, making a separate storm water draining system is the solution to eliminate the chance of sewer overflows during heavy rainfall (EPA, 2011).

Calculation: N/A

Data Source: [Seattle](#), [Davenport](#), [Baltimore](#), [Memphis](#), [Los Angeles](#).

Coverage: 5 cities. Each city was researched individually.

Time Series: 2005 - 2015.

Notes: Flooding hazard indicator.

22. Percent of area that is impervious surface

Description: The percent of areas that are impervious surfaces. Impervious surface lessen the amount of storm water runoff that infiltrate into the ground during excessive rainfall. (impervious).

Rationale: Increasing green space or improving the green storm water infrastructure could offset this disadvantage.

Calculation: This dataset consists of a single layer, percent impervious surface, with file pixel values ranging from 0 to 100 percent, with each individual value representing the area or proportion of that 30m cell covered by developed imperviousness.

Data Source: [Data.gov](#).

Coverage: 5 cities. Nationwide data available.

Time Series: 2001, 2006, and 2011.

Notes: Flooding hazard indicator.

23. Percent land covered by tree canopy

Description: The percent of land covered by tree canopy. Tree canopy is the outer layer of mature leaves and tress. (tree_cover).

Rationale: Green spaces provide passive cooling to mitigate the impact of extreme heat (Gentry et al., 2014).

Calculation: This dataset consists of a single layer, percent tree canopy cover, with file pixel values ranging from 0 to 100 percent, with each individual value representing the area or proportion of that 30m cell covered by tree canopy.

Data Source: [MRLC](#)

Coverage: 5 cities. Nationwide data available,

Time Series: 2001, 2006, and 2011.

Notes: Extreme heat hazard indicator.

24. Percent of adults over the age of 65 that report having influenza in the past 12 months

Description: Percent of adults over the age of 65 that report having an influenza vaccine in past 12 months. (vaccine).

Rationale: Influenza is a common public health concern during cold weather. Higher vaccine rate implies lower sensitivity to the sickness. Meanwhile, influenza vaccine is also a proxy to measure the proportion of the population that has good access to health care, a group that is relatively less sensitive to diseases or injuries caused by climate hazard.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Calculation: The sample respondents of age 65+ who reported influenza vaccination was divided by the sample respondents of age 65+ with valid response to influenza vaccination questions.

Data Source: [Health Indicators Warehouse](#).

Coverage: 5 counties. Nationwide data available.

Time Series: Varied, from 2005 to 2010 for King and Baltimore, 2006 to 2010 for Los Angeles, 2007 to 2010 for Scott, and 2008 to 2010 for Shelby County.

Notes: Extreme heat and extreme cold hazard indicator.

25. Percent of adults who needed to see a doctor but could not because of cost

Description: Percent of adults over the age of 18 who needed to see a doctor but reported they could not because of cost. (delayed_doctor).

Rationale: While the low-income population may be lacking access to home cooling facilities and is therefore particularly vulnerable to extreme heat, they are also less able to afford emergency health care. Making emergency medical facilities more accessible reduces the vulnerability of this group, hence the overall vulnerability of the city.

Calculation: Sample respondents aged 18 years and over who needed to see a doctor but could not because of cost in the past 12 months divided by Sample adults, aged 18 years or older, who live in households, with valid responses to question on delaying health care due to cost. Estimates based on fewer than 50 cases are considered unreliable and are not displayed.

Data Source: [Health Indicators Warehouse](#).

Coverage: 5 counties. Nationwide data available.

Time Series: 2010.

Notes: Extreme heat and extreme cold hazard indicator.

26. Rate among Medicare beneficiaries of inpatient or hospital outpatient emergency department visits

Description: Measured by the rate among Medicare beneficiaries of inpatient or hospital outpatient emergency department visits. (emergency_visit).

Rationale: Emergency department visits is a proxy to measure the capacity of emergency rooms for vulnerable population (the elderly and chronically sick). It seeks to capture the capacity of the medical system to react to a crisis.

Calculation: The number of inpatient or hospital outpatient emergency department visits among Medicare fee-for-service beneficiaries, divided by the number of Medicare fee-for-service beneficiaries.

Data Source: [Health Indicators Warehouse](#).

Coverage: 5 counties. Nationwide data available.

Time Series: 5 years for Baltimore, Scott, Shelby and King (2008 to 2012) and 3 years for Los Angeles (2008, 2010, and 2012)

Notes: Extreme heat and extreme cold hazard indicator.

27. Percent of Medicare beneficiaries eligible for Medicaid

Description: The percent of Medicare (for older individuals) beneficiaries who are also eligible for Medicaid (individuals with limited income or financial resources). (Medicaid)

Rationale: Percent of population that is eligible for Medicaid and Medicare is a proxy measure of vulnerable population in the city (low income, elderly adults, chronically sick)

Calculation: The number of Medicare fee-for-service beneficiaries who are also eligible for Medicaid was divided by the number of Medicare fee-for-service beneficiaries.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Data Source: [Health Indicators Warehouse](#).

Coverage: 5 counties. Nationwide data available.

Time Series: Baltimore: 2008 – 2013, Scott and King: 2008 to 2012, Shelby and Los Angeles: 2008, 2010 and 2012.

Notes: Extreme heat and extreme cold hazard indicator.

28. Number of acute care hospital beds per 1,000 residents

Description: The number of acute care hospital beds available per 1,000 residents in hospital referral areas. (hospital).

Rationale: Hospital beds per capita is a general measure of quality of care.

Calculation: N/A

Data Source: [Becker's Hospital Review](#).

Coverage: 5 cities. Large US cities available.

Time Series: 2012.

Notes: Extreme heat and extreme cold hazard indicator.

29. Access to warming center when the temperature falls below 32 degree

Description: This indicator measured if there is public access to warming centers for times when the temperature falls below 32 degrees Fahrenheit. (warming_centers).

Rationale: In the event of extreme cold hazard, citizens who do not have home heating may rely on publicly available warming centers for heating. Therefore, access is important to enhancing adaptability of a city. This indicator seeks to capture the capacities to provide basic social protection to disadvantaged population when hazard occurs.

Calculation: Binary indicator, 1 meaning yes and 0 meaning no.

Data Source: [Memphis](#), [Baltimore](#), [Davenport](#), [Los Angeles](#), [Seattle](#).

Coverage: 5 cities. Different source for each city.

Time Series: 2015.

Notes: Extreme cold hazard indicator.

Readiness (34 total)

Economic (12 total)

30. Gross production per capita

Description: GDP of a metropolitan area, as a portion of national GDP. GDP is a measure of economic activity, and is the sum of all industry GDPs in the metro area. A metropolitan area is defined by Office of Management and Budget as a geographic area containing a large population center economically and socially integrated with neighboring communities. (gdp).

Rationale: GDP is a signal of the economic robustness of the metropolitan area. Areas with larger GDP tend to have higher business activity, which provides essential resources with which to take adaptation actions and which offers a greater degree of protection against recessions or economic downturns. Growth in GDP per capita generally indicates economic health and greater productivity per individual. However, a higher GDP does not imply equitable adaptation.

Calculation: This indicator is measured in real 2012 dollars (adjusted for inflation) with a base year of 2005. It is based on national prices, and was derived from national chain-type price indexes to current-dollar GDP values for the 61 NAICS-based industries.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Data Source: [Bureau of Economic Analysis - US Department of Commerce.](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2009 – 2012.

Notes: GDP by metro area does not account for regional differences in prices of goods and services that are produced and sold locally. The statistics do not account for revisions to the national income and product accounts that were released in July 2013, and are based on source data that are subject to change or are incomplete.

31. Percent of population in poverty

Description: This indicator measures the percent of a city's population with poverty status in a given year, based on the American Community Survey. Numbers of individuals in poverty is categorized by variables such as age, sex, race, educational attainment, employment status, and work experience. (poverty).

Rationale: Population in poverty has less resources to deal with climate hazards (Adger, 2001)

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 - 2014.

Notes:

32. Dependence on internal cash flow versus imported cash flow

Description: This indicator is derived from selected economic characteristics, based on five-year estimates from the American Community Survey in 2010-2014. It determines how much of the city's cash flow is generated internally, as opposed to externally. Estimates are categorized according to variables such as employment status, commuting to work, occupation, industry, class of worker, income and benefits, health insurance coverage, and percent of families with income below the poverty level. (cash_source).

Rationale: Internal cash flow signifies ownership of profitable assets, which is an advantage in creating a strong economy. Economies that are strong and diverse are better able to support businesses amidst climate change risk and are better equipped to recover from climate events (International Finance Corporation, 2010).

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates.](#)

Coverage: 5 cities. Nationwide data available.

Time Series: Five year estimates 2010-2014.

Notes:

33. State minimum wage

Description: Minimum wage required by each of the fifty states, US territories, and federal government. The minimum wage is measure in US dollars per hour currently, but in previous years was occasionally measured in dollars or cents per week. (wage).

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Rationale: States with lower minimum wages may have a larger low-income population, reducing the overall capabilities to cope with serious climate-related events. The impacts of climate change most heavily affect areas that are already experiencing economic difficulties (U.S. Department of Labor, 2014). Higher minimum wages have the potential to allow full-time workers to earn more than poverty level income (Neumark, 2015).

Calculation: N/A

Data Source: Compilation of data obtained from the [US Department of Labor](#), but sourced from the Book of States, 1968-1999 edition, volume 32; and the U.S. Department of Labor, Office of State Standards Programs Wage and Hour Division website, Minimum Wage and Overtime Pay Standards Applicable to Nonsupervisory NONFARM Private Sector Employment Under State and Federal Laws.

Coverage: State level data for all 5 cities. Nationwide data available.

Time Series: 2005 – 2015.

Notes: Wage rates are for January 1 of each year except 1968 and 1972, which show rates as of February. A range of rates, as in Puerto Rico, reflects which rates differ by industry, occupation or other factors, as established under a wage-board type law. Wage rates in bold indicate an increase over the previous year's rate.

34. Household average income

Description: Average annual income per household for selected cities. Data is further broken down into categories such as race, sex, age, household relationships, type of household, marital status, school enrollment, education, fertility, responsibility for grandchildren under 18 years of age, veteran and disability status, residence one year ago, place of birth, citizenship status, language spoken at home, employment, occupation, health insurance coverage, structure of household, and vehicles available. (hhincome).

Rationale: A higher average income per household generally indicates a higher level of economic resilience (USAID, n.d.)

Calculation: The boundaries of urban areas are determined by Census data. Estimates based on survey data from the American Community Survey 1-Year Estimates.

Data Source: [United States Census Bureau – American Fact Finder, American Community Surveys 1-Year Estimates](#).

Coverage: 5 cities. Nationwide data available.

Time Series: 2010-2014.

Notes:

35. City government deficit/surplus ratio

Description: The general fund operating surplus or deficit as a percent of total operating expenses on an actual basis (as opposed to the budgeted basis). The focus of this indicator is on the completed years, rather than projections of surplus or deficit for future years. (pbfinance).

Rationale: Generally, an indication of financial health of local governments. A surplus indicates that sufficient funds are available to cover necessary and desired spending. However, a large surplus does not guarantee a strong economy or healthy financials (Norcross, 2015). A lower deficit/surplus ratio implies a higher chance for the government to be resilient in a difficult year because of climate disasters.

Calculation: The ratio is calculated as the general fund operating surplus or deficit divided by the total operating expenses for each fiscal year.

Data Source: [The Civic Federation](#), originally sourced from Local Government Comprehensive Annual Financial Reports, FY 2006 – FY 2010.

Coverage: Ratios calculated for Atlanta, Baltimore, Boston, Chicago, Columbus, Detroit, Kansas City, Los Angeles, New York, Philadelphia, Phoenix, Pittsburgh, and Seattle.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Time Series: 2006 – 2010.

Notes: Due to a change in their fiscal year, Atlanta's FY 2006 data reflects the 6 months ended June 30, 2006.

36. Percent civilian unemployment

Description: The unemployment rate for civilians at least 16 years old in given cities (unemployment rate population 16 years and older). (unemployment).

Rationale: Cities with higher rates of unemployment will generally have a greater proportion of individuals who are unable to cope with economic shocks because they typically lack a steady income stream.

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data. Data collected from the American Community Survey One-Year Estimates.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005-2014.

Notes:

37. Median house value

Description: Median house values, in dollars, in given cities. Houses defined as owner-occupied housing units. (median_value).

Rationale: Higher median house value tends to be associated with higher property damage when hazard occurs. However, higher house value can also be associated with economically better-off population, whose adaptability to future climate impacts and resilience to cope with climate hazards are stronger.

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data. The values reflect the median for the sample of surveys collected.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 – 2014.

Notes:

38. Percent of households receiving Social Security

Description: The percent of households receiving social security income in a given year in selected cities. Data provides estimate of total number of household with social security income within the past 12 months, and the total number of households with no social security income within the past 12 months. (social_security).

Rationale: A greater percent of households relying on or receiving social security income would tend to create extra stress on the government in the event of economic difficulties.

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#).

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 – 2014.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Notes:

39. Percent of females between age 20 and 64 that are in the labor force

Description: The percent of total females between the ages of 20 and 64 within a city's population that are part of the labor force. (female).

Rationale: Gender equality, partly indicated by female participation in a society's economy, is an important component of social equity. Societies that enjoy higher degree of equity tend to be more resilient to external shocks and stresses including climate change impacts (The World Bank Group, 2011). The mechanism of such hypothetical relationship is pending for more research.

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 5-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2009 - 2014.

Notes:

40. Percent of employed population 16 years and older employed in service occupation

Description: Of the employed population at least 16 years old, the percent who are employed in a service occupation. Data is categorized according to both industry and occupation. (service).

Rationale: Compared to traditional agriculture, fishery, and manufacturing industries, people employed in service industry are in general less vulnerable to the impact of climate change (Kim, et al., 2016).

Calculation: Data is derived from samples of each city's population, and the presented numbers and calculations are based on a 90 percent margin of error. The boundaries of urban areas are determined by Census data.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 - 2014.

Notes:

41. Gini coefficient of household income inequality

Description: The Gini coefficient measures the income inequality per household in a given area, with values between zero and one (or zero to one hundred). A value of one would reflect all income concentrated in one household. (gini).

Rationale: Social inequality exacerbates a society's capabilities to adapt to climate change. Gini coefficient as an indication of income equality quantifies one type of social inequality that would possibly affect the overall adaptive capacity (African Development Bank et al., 2002).

Calculation: The Gini coefficient is a ratio that is calculated as the area between the Lorenz curve and the line of equality divided by the area below the line of equality. The data is based on 95% confidence intervals prior to 2006, and 90% confidence intervals from 2006 onward.

Data Source: The data is summarized by the [Health Indicators Warehouse](#), but was sourced from the [American Community Survey](#), conducted by the [US Census Bureau](#). For sparsely populated states in 2005-2007, Mark L.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Burkey, Assistant Professor of Economics and NCA&T State University in Greensboro, NC, provided estimates.

Coverage: 5 cities. Nationwide data available.

Time Series: 2005-2013.

Notes:

Governance (8 total)

42. The degree of government's dedication to climate change adaptation

Description: The degree of government's dedication to climate change adaptation is represented by the number of adaptation and resiliency networks and organization to which the city belongs. Measured by participation in 100 Resilient Cities, STAR Communities, C40, CDP, USDN, and others. (network).

Rationale: Cities that are more dedicated to adaptation and resilience will be more likely to belong to the aforementioned networks.

Calculation: The total number of networks (or total sum).

Data Source: [100 Resilient Cities](#), [STAR Communities](#), [C40](#), [CDP](#), [USDN](#), and [World Mayors Council](#).

Coverage: 5 cities. Data gathered based on pilot cities only.

Time Series: 2015.

Notes:

43. Transparency and accountability in governance

Description: The level of transparency in a local government as measured by Ballotopedia. (gov).

Rationale: Ballotopedia (an online encyclopedia for elections) has a 10-point transparency checklist for American governments. Transparency is highly correlated with good governance and social scientists generally equate it to stronger government outcomes.

Calculation: Score based on Ballotopedia analysis.

Data Source: [Ballotopedia](#).

Coverage: 5 cities. Data available for most major US cities.

Time Series: 2015.

Notes:

44. Total number of police officers per 10,000 residents

Description: The total number of police officers per 10,000 residents. (police).

Rationale: A common metric of public safety is the number of public safety workers per resident. But each city defines public safety differently. Police are universal. And so, their ratio to the population is a proxy for public safety workers. Thus, the strength of public safety can be measured through this ratio.

Calculation: Total number of police officers per 10,000 residents.

Data Source: [governing.com](#).

Coverage: 5 cities. Data available for most major US cities.

Time Series: 2010 and 2012.

Notes:

45. Civic engagement

Description: Voter turnout in federal general elections. (turnout).

Rationale: Voter turnout rates are a proxy for the level of involvement a community experiences. Higher voter turnout indicates an electorate that is engaged and cares about public policy.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Calculation: Votes cast per eligible voter.

Data Source: [Baltimore](#), [Davenport](#), [Los Angeles](#), [Memphis](#), [Seattle](#).

Coverage: 5 counties. Data gathered from secretaries of state, respectively.

Time Series: 2008 and 2012.

Notes:

46. Total number of federal public corruption convictions

Description: The total number of federal public corruption convictions. (corruption_convictions).

Rationale: Corruption convictions are indicative of a local government's transparency and accountability.

Calculation: Sum of total convictions.

Data Source: [Justice Department](#).

Coverage: 5 cities. Data available by district of the US Attorney's Office.

Time Series: 2005-2013.

Notes:

47. Tax incentives for adaptation investment

Description: Tax incentives for adaptation investment.

Rationale: Economic incentives for adaptation encourage actions on the local level. It also indicates the local government is prioritizing adaptive actions.

Calculation: Binary indicator, 1 is yes, 0 is no.

Data Source: Different for each city.

Coverage: Los Angeles and Seattle. Data gathered from cities directly.

Time Series: 2009 – 2015 (Los Angeles) and 2005 – 2015 (Seattle).

Notes:

48. Existence of a city wide siren alert system

Description: If a city does or does not have a siren alert system for use in case of emergencies. (sirens).

Rationale: A wide siren alert system is vital to curbing potential damage and even loss of life in the case of extreme events.

Calculation: Binary indicator where 1 means yes and 0 means no.

Data Source: [Baltimore](#), [Davenport](#), [Memphis](#), [Seattle](#).

Coverage: 5 cities. Data gathered from cities directly.

Time Series: 2015.

Notes:

49. Existence of city wide warning systems

Description: City wide warning systems that reach people with either with phone call, email, or text alert which are distinct from sirens. (warning_systems).

Rationale: Siren systems are not the only way to alert communities to disasters, other modes of emergency alerts must be captured.

Calculation: Binary indicator where 1 means yes and 0 means no.

Data Source: [BCRP Recreation Centers](#), [Los Angeles.com: Community Centers in Los Angeles](#)", [Davenport Iowa Website](#), [The City of Memphis: "Community Centers"](#), [Seattle Parks and Recreation Department](#).

Coverage: 5 cities. Data gathered from cities directly.

Time Series: 2015.

Notes:

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Social (14 total)

50. General innovation capabilities

Description: The number of patents per 1,000 jobs. (inno)

Rationale: Patents require creativity and resources, both of which enable better disaster response. Therefore a high number of patents is one signal that a society will have the resilience to effectively encounter change. (*Patenting and Innovation in Metropolitan America*, 2013).

Calculation: The average of the number of patents divided by every 1,000 jobs from 2007 to 2011

Data Source: [Brookings](#)

Coverage: 5 cities. Most major American cities included.

Time Series: Single projection.

Notes:

51. Estimated percent of adults who think global warming is already harming people in the US now or within 10 years

Description: The estimated percent of a county that believes that global warming is already harming people in the US or will harm people in the US within 10 years. (harmUS_now).

Rationale: Risk perception is a large determinant in whether or not people will act (Leiserowitz, Anthony, n.d.). If people do not think that global warming is likely to harm them in the near future, they are not likely to prepare for the increased natural disasters that global warming will bring and will have a greater chance of being negatively affected by such disasters.

Calculation:

Data Source: [Yale Project on Climate Change Communication](#)

Coverage: 5 counties. Nationwide data available.

Time Series: 2014.

Notes:

52. Estimated percent of adults who think global warming will harm people in the US

Description: The estimated percent of a county that believes that global warming will harm people in the US. (harmUS_future).

Rationale: Risk perception is a large determinant in whether or not people will act preemptively. If people do not think global warming will harm people in the US they are unlikely to prepare for the increased natural disasters that global warming will bring and they are especially unlikely to make preemptive lifestyle changes in order to adapt if they do not expect to be harmed by the changing world.

Calculation:

Data Source: [Yale Project on Climate Change Communication](#)

Coverage: 5 counties. Nationwide data available.

Time Series: 2014.

Notes:

53. Percent of population speaking only majority language

Description: The percent of the population of a city age five and over that speaks only the majority language (English in the United States). (language).

Rationale: Communication is crucial in both preparing for and responding to disasters and in a resilient community (Scott, John, 2007), there is high level of communication across different social groups. The language barrier between majority and minority populations could keep individuals from working together in an

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

emergency.

Calculation: N/A

Data Source: [U.S. Census Bureau](#)

Coverage: 5 counties. Nationwide data available.

Time Series: Annual from 2010 to 2013.

Notes:

54. Percent of a population speaking the majority language at least very well

Description: The percent of the population of a city age five and over that speaks the majority language at least “very well” (English in the United States). (language2).

Rationale: Communication is crucial in both preparing for and responding to disasters and it is especially important to understand public warnings and emergency information, which are usually distributed in the majority language. Speaking the majority language at least very well may help individuals effectively respond to disasters.

Calculation: N/A

Data Source: [U.S. Census Bureau](#)

Coverage: 5 counties. Nationwide data available.

Time Series: 2010 – 2013.

Notes:

55. Existence of neighborhood watch program

Description: Whether or not a city has a neighborhood watch program. (neighborhood).

Rationale: Neighborhood watch programs can increase feelings of trust and reciprocity of those on the watch, predisposing them to work together and effectively respond to emergencies.

Calculation: Binary indicator. If city resources mention a neighborhood watch program for a specific year, the watch program is recorded for that year and all following years

Data Source: [Baltimore Police Department](#), [LAPD](#), [Quad City Times](#), [Memphis Police Department](#), [Seattle Police Department](#).

Coverage: 5 cities. Data gathered directly from city sources.

Time Series: Varies by city depending on available data, beginning with 2005 Davenport, Memphis and Seattle, and 2015 for Baltimore and Los Angeles

Notes:

56. Existence of community centers

Description: Whether or not a city has community centers. (center).

Rationale: Social capital (connections between individuals) tends to increase a city’s resilience. Relationships of trust and teamwork enable communities to work together in the face of disaster and such relationships are fostered in regular community engagement (*A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action*, 2011), such as at community center functions.

Calculation: Binary indicator. If city resources mention a community center for a specific year, the community center is recorded for that year and all following years

Data Source: [BCRP Recreation Centers](#), [Los Angeles.com: “Community Centers in Los Angeles”](#), [Davenport Iowa Website](#), [The City of Memphis: “Community Centers”](#), [Seattle Parks and Recreation Department](#)

Coverage: 5 cities. Data gathered directly from city sources.

Time Series: 2005 – 2015.

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Notes:

57. Percent of the population with less than 12th grade education

Description: Percent of the population over 18 years old with no high school diploma. (incomplete_ed).

Rationale: Education provides increased job options. High levels of career flexibility enable one to make a livelihood in a variety of places and with various resources. This flexibility helps individuals to effectively adapt to lifestyle changes that may come from natural disasters.

Calculation: Sum of the percent of the population 18-24 years old with less than high school diploma and percent of population over 25 years old with less than 9th and percent of population over 25 years old with no high school diploma.

Data Source: [U.S. Census Bureau](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 – 2014.

Notes:

58. Percent of workers 16 years and older with no vehicle

Description: The percent of workers 16 years and older that do not have a vehicle. (no_car).

Rationale: An individual without a vehicle may rely on walking, biking, carpooling or public transportation to get to work. Any of these activities can easily be compromised by extreme heat or cold events, sickness or unpredictable situations. Thus, in extreme situations these individuals are less likely to get to work and less likely to maintain their income when resources may be most necessary.

Calculation: N/A

Data Source: [U.S. Census Bureau](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 – 2014.

Notes:

59. Number of reported property crime offenses per 100,000 of the population

Description: The number of property crimes, including burglary, larceny, theft and motor vehicle theft, reported to the city's police departments per 100,000 of the population covered. (property_crime).

Rationale: Property crimes decrease a community's sense of safety and trust, both of which are crucial elements of a cohesive society. Cohesive societies are better able to work together and respond to disasters than fragmented communities (Patterson, Weil, Patel, 2010) whose members are less likely to reach out or collaborate under stress.

Calculation: The total number of reported property crimes divided by the population coverage divided by 100,000

Data Source: [U.S. Department of Justice](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2005 – 2012.

Notes:

60. Percent of total students eligible to participate in the National School Lunch Program under the Free Lunch Act

Description: The percent of the total students that are eligible to participate in the National School Lunch Program under the Free Lunch Act. (free_lunch).

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

Rationale: Lower income families that depend on national programs such as these are most likely to lose access to essential resources if disaster strikes and effective aide is not available.

Calculation: N/A

Data Source: [Health Indicators Warehouse](#)

Coverage: 5 cities. Nationwide data available.

Time Series: Irregular varying by city; reporting in 2008, 2011, 2012 and 2013

Notes:

61. Percent of buildings that are LEED approved

Description: Percent of buildings that are LEED approved. (LEED).

Rationale: LEED approved buildings use fewer resources, and are therefore less taxing on the resource and energy supply. These supplies may become critical during disasters and emergencies.

Calculation: Number of LEED approved buildings over the total number of buildings.

Data Source: [Green Building Information Gateway](#)

Coverage: 5 cities. Some data for US cities available.

Time Series: 2015.

Notes:

62. Percent of total population with Food Stamp/SNAP benefits in the past 12 months

Description: Percent of the total population that used Food Stamp or SNAP benefits in the past 12 months. The data is also broken down into categories, providing the percents for the population with a given characteristic, such as poverty status, disability status, race, income, and work status. (food_stamp).

Rationale: Individuals using food stamps are of a lower socioeconomic status, and will likely be more heavily affected by an event that strains the government and/or their resources.

Calculation: Data is based on 90% margin of error.

Data Source: [United States Census Bureau – American Fact Finder, American Community Survey 1-Year Estimates](#)

Coverage: 5 cities. Nationwide data available.

Time Series: 2013 – 2014.

Notes:

63. Existence of energy cost saving programs for the poor

Description: Whether or not the city has cost saving programs for the poor. (cost_save).

Rationale: Energy is a major expense but also crucial for maintaining livelihoods in extreme heat or cold events. Expanding energy access to poor and vulnerable communities is important for resilience.

Calculation: Binary indicator. If city resources mention a cost savings programs for the poor the program is recorded.

Data Source: [Seattle.gov](#) [Baltimore County Government](#) [Shelby County Tennessee](#)

Coverage: 3 cities. Data gathered directly from city sources.

Time Series: 2015.

Notes:

ND-GAIN's Pilot Urban Adaptation Assessment Technical Document

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