ND-GAIN Urban Adaptation Assessment

4/5 of the top **global risks** in the next **10 years** are related to **CLIMATE CHANGE** { World Economic Forum 2016

#1 Global risk in terms of **impact** is failure to respond to climate change

Though these risks are often discussed at the national scale, urban areas are increasingly seen as having a role on the climate agenda. Despite this need, decision-makers face significant challenges including:

- Uncertainty of urban climate hazards
- Lack of measurement to prioritize adaptation actions
- Lack of data to understand & track urban vulnerability to climate change
- Difficulty integrating adaptation information into current procedures

Responding to the need for increased urban resilience and adaptation planning, the **Urban Adaptation Assessment** project, funded by the **Kresge Foundation** and led by the **Notre Dame Global Adaptation Initiative (ND-GAIN),** provides an adaptation measurement solution that can be scaled around the world to identify key climate risks and adaptation options for cities.

Many frameworks exist to measure vulnerability to the changing climate at the city level. However, current literature lacks assessment of cities' capacity to take on adaptation action and to reduce losses and damages arising from climate hazards. This work aims to advance the knowledge of adaptation by building a better understanding of how climate change affects U.S. cities and exploring the connection between adaptive capacities and the impacts of climate disasters.

This project helps elevate critical needs on climate actions and thereby **inform decisions about infrastructure, land use, water resources management, transportation and other policy and funding issues such that communities are motivated to act and build a resilient future.**

Funded by

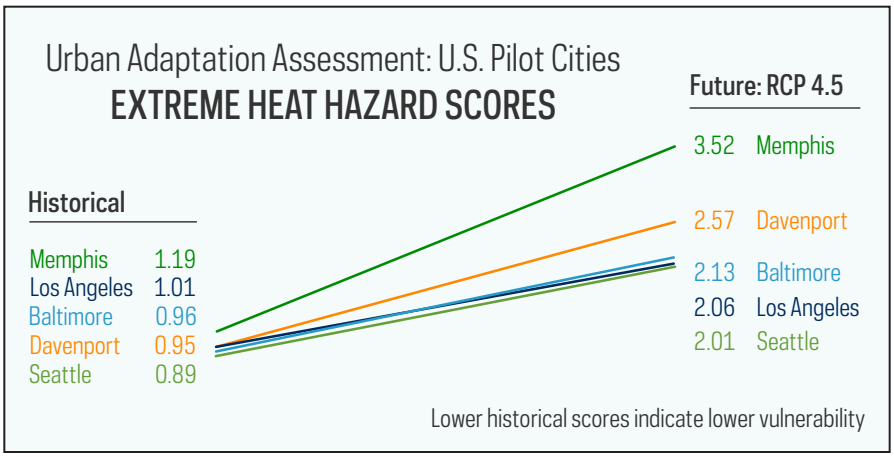
THE KRESGE FOUNDATION

ND-GAIN Urban Adaptation Assessment

U.S. PILOT CITIES >>>

Beginning in early 2015, the ND-GAIN team established collaborations with a robust advisory committee of 30+ leading U.S. adaptation experts, including both researchers and practitioners working on resilience, who inform the project.

By building a forward-looking framework to assess the vulnerability and adaptive capacity for five U.S. cities, this work presents analysis of each city and comparisons among them to demonstrate the utility of the framework for national and international use.



<<< ILLUSTRATIVE FINDINGS

Urban Adaptation Assessment pilot results show a dramatic increase in the extreme heat hazard for each city. Findings compare historical data with future climate scenarios.

The project's publicly accessible resources can be viewed on the Adaptation Collaboratory: adapt.nd.edu/groups/ndgainurban.

In late 2016, ND-GAIN aims to expand the Urban Adaptation Assessment project from five pilot cities to 254 cities, which will include all U.S. cities with population above 100,000. The larger sample size will allow the assessment to identify key adaptation actions, generalizable to global cities, adaptation patterns among a certain subset of cities (i.e. coastal cities), and indicators that have a strong relationship with reducing sensitivity and improving capacity.

The next phase of the project will also look at addressing social inequities in urban adaptation to climate change. The expansion will develop wider visibility and use of the assessment for city government and community leaders' decision-making.

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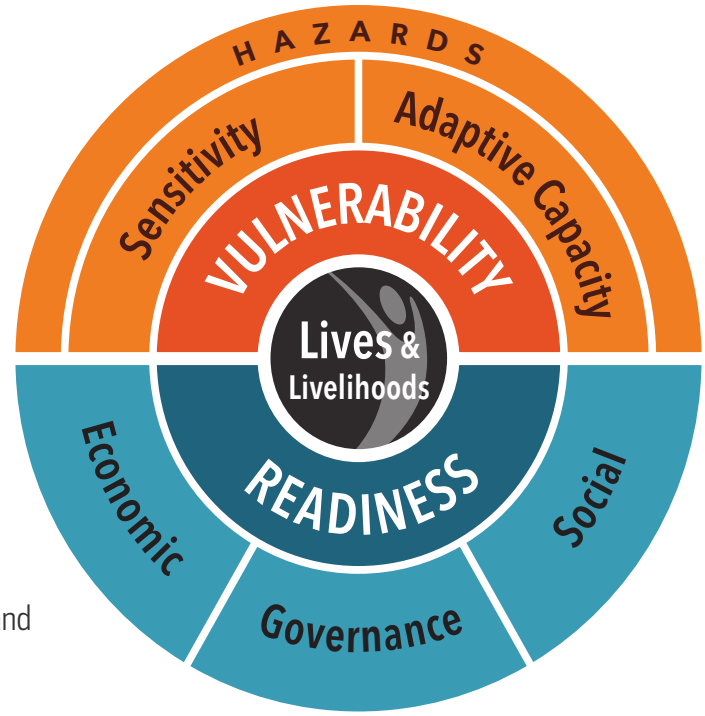
ASSESSMENT COMPONENTS >>>

The assessment consists of three broad components used to measure a city's overall adaptability:



1. VULNERABILITY

Degree to which an urban area is unable to cope with the impacts of climate hazards on its human population.[1] Vulnerability is a function of the hazard, a city's sensitivity to the hazard, and its adaptive capacity.

2. READINESS

General features of urban areas that will enable policy change and action implementation to reduce vulnerability to climate hazards. Readiness is composed of the measure of economic conditions, governance support and social capacities.

3. LIVES AND LIVELIHOODS

Impact of climate hazards on a city, to be specific, on lives (injuries and fatalities) and on livelihoods (property damage).

The above visual serves as a theoretical foundation. Each component corresponds to a series of indicators that are then combined to generate **four distinct score for each city**:

score	HAZARD INCLUDES FLOODING, EXTREME HEAT & EXTREME COLD INDICATORS	CONDITION INCLUDES SENSITIVITY, ADAPTIVE CAPACITY & READINESS INDICATORS	HAZARD-SPECIFIC ADAPTATION	OVERALL ADAPTATION
definition	City's climate-hazard risk that reflects the hazard's magnitude	City's distance to the best performer in the sample, in terms of its conditions to cope with one particular climate hazard, without accounting for that climate hazard's risk	City's level of adaptation to a particular hazard, accounting for climate risk	City's level of adaptation to all included hazards, accounting for climate risk
values	0 to (+) ∞ Lower is better	0 to 1 Lower is better	0 to (+) ∞ Lower is better	0 to (+) ∞ Lower is better
# scores	One score per hazard for historical and two future	One score per hazard for vulnerability & readiness	One score per hazard for historical and two future	One score for historical and two future

1. UAA pilot hazards include extreme heat, extreme cold and flooding.

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FRAMEWORK & METHODOLOGY

HAZARD SCORES

downscale hazard data

- Acquire data from the Downscaled CMIP3 & CMIP5 Climate & Hydrology Projections archive (statistically downscaled to a 0.125-degree spatial scale)

calculate probability distributions

- Gather data at city's geographical centroid for each hazard index/year from 1950-1999 (historic)
- Estimate probability density functions of each hazard index magnitude using the average shifted histogram method
- Convert to probability distributions by dividing each bin's midpoint density by the total density
- Gather city forecast data for each hazard index/year from 2020-2049 (future) for RCP 4.5 & 8.5 scenarios

convert to expected values

- Calculate the 50-year average value of each hazard index (one per index per city from the historical distributions and one per index per city per year from each of the two RCP scenarios)
- For future projections, average expected values over 2020-2049 and calculate the 30-year average value of each hazard index

normalize expected values

- Divide historical expected values and each forecast year's expected values by each index's across-city historical mean, thus calculating each hazard score

CONDITION SCORES

gather indicator data

- Gather data for indicators corresponding to the sensitivity, adaptive capacity, & all readiness components of the UAA framework from public databases & cities' public documents
- Gather outcome data for lives lost, injured & extent of property damage from historical hazard events from SHELDUS

conduct correlation analysis

- Correlate adaptive capacity & sensitivity indicators only with the relevant hazard outcome data
- Correlate readiness indicators with each set of hazard outcome data

define adaptation frontier

- Identify the "best value" or adaptation frontier in the sample for each indicator (if the correlation coefficient was negative, the frontier value is the maximum value in the sample and visa versa)

compare with frontier

- Standardize indicator data by measuring each value's distance to the frontier, weighted by the absolute value of the correlation coefficient

average scores

- Average scores of all the indicators for the extreme heat, extreme cold, and flooding hazards

HAZARD SPECIFIC ADAPTATION SCORES

Hazard Scores * Condition Scores = Hazard Specific Adaptation Scores

OVERALL ADAPTATION SCORES

Average of Hazard Specific Adaptation Scores = Overall Adaptation Scores

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INDICATOR LIST

VULNERABILITY

Degree to which an urban area is unable to cope with the impacts of three primary climate hazards on its human population. Vulnerability is a function of the hazard, a city's sensitivity to the hazard, and its adaptive capacity.

HAZARD Potential occurrence of a biophysical event, trend or impact caused by climate change. Quantified by projection of hazard magnitude 1950-99 (historic) & 2020-2049 (future).	SENSITIVITY 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 Measures to what extent an urban area is capable of minimizing the impacts of climate hazard, e.g. the number of medical facilities.
FLOODING Rx5day: Monthly maximum consecutive 5-day precipitation	Percent of vulnerable population living or residing in informal settlements	Frequency of public transportation use (measured by the trips taken via public transit per capita)
	Average age of buildings	
	Quality drinking water (measured by coliform reading)	
	Percent of vulnerable population under 18 years old	Frequency of public transportation use (measured by the trips taken via public transit per capita)
	Percent of vulnerable population that is 75+ years old	
	Percent of vulnerable population with poor or fair health conditions	
	Percent of uninsured vulnerable population	Percent of area that is impervious surface
	Percent of bridges in the city at risk to flooding	
	Percent of total length of roads at risk to flooding	
EXTREME HEAT WSDI: Warm spell duration index Annual count of days with at least 6 consecutive days when daily maximum temperature higher than the 90 percentile of the maximum temperature in the base period	Level of energy consumption per customer (measured in megawatt hours)	Percent of land covered by tree canopy
	Average price of a megawatt hour in cents for electricity	Percent of adults over the age of 65 that report having an influenza vaccine in past 12 months
	Percent of vulnerable population under 18 years old	Percent of adults who needed to see a doctor but could not because of cost
	Percent of vulnerable population that is 75+ years old	
	Percent of vulnerable population with poor or fair health conditions	Rate among Medicare beneficiaries of inpatient or hospital outpatient emergency department visits
	Percent of uninsured vulnerable population	Percent of Medicare beneficiaries eligible for Medicaid
	Percent of housing units with air conditioning	Acute care hospital beds available per 1,000 residents
EXTREME COLD CSDI: Cold spell duration index Annual count of days with at least 6 consecutive days when the daily maximum temperature lower than the 10 percentile of the maximum temperature in the base period	Level of energy consumption per customer (measured in megawatt hours)	Access to warming centers when the temperature falls below 32 degree
	Average price of a megawatt hour in cents for electricity	Percent of adults over age of 65 that report having an influenza vaccine in past 12 months
		Percent of adults who needed to see a doctor but could not because of cost
	Percent of housing units with heating fuel available	Rate among Medicare beneficiaries of inpatient or hospital outpatient emergency visits
	Percent of housing units with heating equipment that reported heating problems	Percent of Medicare beneficiaries eligible for Medicaid
		Acute care hospital beds available per 1,000 residents

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INDICATOR LIST

READINESS

General features of urban areas that will enable policy change and action implementation to reduce vulnerability to climate hazards. Readiness is composed of the measure of economic conditions, governance support, and social capacities. It is also known as generic adaptive capacity.

GOVERNANCE INDICATORS	ECONOMIC INDICATORS	SOCIAL INDICATORS
Degree of government's dedication to climate change adaptation (measured by participation in 100 Resilient Cities, STAR Communities, C40, CDP, USDN, and World Mayors Council)	Gross production per capita	General innovation capabilities (measured by number of patents per 1,000 jobs)
	Percent of population in poverty	Estimated percent of adults who think global warming is already harming people in the US now or within 10 years
Transparency & accountability in governance (measured by Ballotopedia's 10-point transparency checklist)	Dependence on internal cash flow versus imported cash flow	Estimated percent of adults who think global warming will harm people in the US
	State minimum wage	Percent of population speaking only majority language
Total number of police officers per 10,000 residents	Household average income	Percent of population speaking majority language at least very well
	City government deficit/surplus ratio	Existence of neighborhood watch program
Civic engagement (voter turnout in federal general elections)	Percent civilian unemployment (unemployment rate population 16+ years)	Existence of community centers
		Percent of population with less than 12th grade education
Total number of federal public corruption convictions	Median house value	Percent of workers 16 years+ with no vehicle
	Percent of households receiving social security	Number of reported property crime offenses per 100,000 of the population
Tax incentives for adaptation investment	Percent of females between age 20 and 64 that in the labor force	Percent of total students eligible to participate in National School Lunch Program under Free Lunch Act
Existence of a city-wide siren alert system	Percent of employed population 16+ years employed in service occupation	Percent of total population with Food Stamp/ SNAP benefits in past 12 months
		Existence of energy cost saving poor programs
Existence of city wide warning systems	Gini coefficient of household income inequality	Percent of buildings that are LEED approved

To learn more about the the Urban Adaptation Assessment's framework and methodology, view our technical document:
gain.org/sites/default/files/UAATechnical.pdf

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