NYC URI 2.1

Urban Risk Index Methodology

February 2025

NYCEM
New York City Emergency Management

Outline

Urban Risk Index Overview

Background

The New York City (NYC) Urban Risk Index (URI) is a tool developed by NYC Emergency Management (NYCEM) to assess relative hazard risks and NYC's current risk mitigation capacity. The URI builds on methodology laid out in FEMA's National Risk Index (NRI), using more local and up-to-date data to better represent relative risk across the City.

The URI is composed of three main components:

- The risk evaluation methodology, including a detailed inventory of data.
- The codebase to process data and calculate risk scores.
- A visualization tool to view and help interpret results.

The first iteration of the URI (URI 1.0) was developed after the 2019 NYC Hazard Mitigation Plan (HMP) as an enhancement to the Risk Assessment portion of the plan. As part of the 2024 NYC HMP update, NYCEM embarked on an effort to update the data and key pieces of methodology driving the URI, streamline the codebase, and create a public-facing dashboard for disseminating results of the updated URI (URI 2.1).

This document outlines the basics of the URI calculation for each hazard, including key data sources and methodologies. More detail can be found in the URI 1.0 Technical Documentation and URI 2.1 Methodology Updates.

Approach

The New York City (NYC) Urban Risk Index (URI) assesses risk based on the spatial distribution of Hazard Impacts, Social Vulnerability, and Resilience Capacity as relevant to six physical hazards described in the NYC Hazard Mitigation Plan (HMP). The URI builds off the framework established by the Federal Emergency Management Agency's (FEMA's) National Risk Index (NRI) and other research efforts attempting to quantify and rank elements of risk, vulnerability, and resilience, but tailors this information to NYC's specific context, leveraging locally-generated data assets and research whenever available.

The URI defines risk with three primary components: Hazard Impacts, Social Vulnerability and Resilience Capacity.

- **Hazard Impacts** represent the potential loss resulting from a hazard across a variety of factors, including mortality loss, morbidity loss, property loss, environmental loss, response costs, and indirect costs.
- **Social Vulnerability** considers demographic factors that increase the likelihood of individuals or communities experiencing harm during and after a hazard event.
- **Resilience Capacity** assesses the ability of individuals and communities to prepare for, adapt to, withstand, and recover from the effects a hazard event.

$$\text{Risk} = \text{Hazard Impacts} \times \text{Social Vulnerability} \div \text{Resilience Capacity}$$

In the URI, Social Vulnerability is considered a consequence-intensifying component and Resilience Capacity is a consequence-reducing component. These three components are used to calculate a total Risk Score, as shown in the equation above

Hazard Summary

A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage. As described below, these hazards can impact communities in many ways and are not mutually exclusive. For some hazards, it was possible to quantify the highest value impacts using existing datasets; however, not all impacts are straightforward to isolate and quantify. For example, the URI for the winter weather hazard does not include flood impacts, even though recent winter storms have caused significant flooding. The table below summarizes the hazards evaluated in the URI, while the next slides discuss the calculation methodologies and breakdown of factors for each hazard.

Label	Hazard	Description
CER	Coastal Erosion	Coastal erosion is the loss or displacement of land along NYC’s coastline from the interaction of oceans, waves, and beaches, often coupled with the impact of human activity. Coastal erosion rates can be highly variable and driven by large events such as nor’easters and hurricanes. For example, according to U.S. Army Corps of Engineers estimates, Hurricane Sandy in 2012 eroded over 4 million cubic yards of soil from the NYC coastline. NYC has identified coastal erosion hazard areas (CEHAs) where erosion is more likely due to local geology, coastal hydrodynamics, and historical erosion / deposition rates.
CSF	Coastal Storm Flooding	Coastal storm flooding occurs when storm systems such as hurricanes, tropical storms, and extratropical cyclones (nor'easters) generate elevated water levels along coastlines that are typically referred to as storm surge. As illustrated by Hurricane Sandy in 2012, low-lying areas of NYC’s coastline are highly vulnerable to storm surge and storm surge-related damage. In addition to storm surge, coastal storms can also produce high waves and significant inland flooding. However, these additional factors were not considered for the coastal storm flooding URI. Only storm surge flooding in the absence of wave impacts and rainfall flooding, sometimes known as stillwater flooding, is considered.
CSW	Coastal Storm Winds	Coastal storm winds are strong, high-velocity winds generated by coastal storm systems such as hurricanes, tropical cyclones, and extratropical cyclones (nor’easters). The intense winds are not only a key cause of storm surge, but can directly damage buildings, infrastructure, and vegetation. Intense winds from coastal storms can also generate flying debris, which can cause additional damage and are particularly hazardous to human health. Although intense winds can also arise from other weather phenomena, such as low atmospheric pressure, thunderstorms, tornadoes, and microbursts, only coastal storm systems are considered for the URI due to data limitations.

Hazard Summary

Label	Hazard	Description
ERQ	Earth-quakes	Earthquakes are a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the surface. Large seismic events damage buildings and their inhabitants, as well as transportation infrastructure and utilities. The largest recorded earthquake in NYC occurred in 1884 with an estimated magnitude of 5.2 on the Richter scale. If this same earthquake were to occur today, one model suggests it would cause $4.7 billion dollars in damages and generate 493,000 tons of debris.
EXH	Extreme Heat	Extreme heat events in NYC cause dehydration, heat exhaustion, heat stroke, and in extreme cases, death. Extreme heat events also increase demand for air conditioning, stressing the power grid and causing outages. Due to the heat island effect, extreme temperatures can be especially common in the most densely developed parts of the city that have high amounts of concrete and low vegetation and tree coverage. NYC defines extreme heat events as periods when the heat index (which measures how hot it feels as a combination of temperature and relative humidity) is 100 degrees Fahrenheit or higher for one or more days, or when the heat index is 95 degrees Fahrenheit for two or more consecutive days. According to the NYC Hazards History and Consequences database, over 80 extreme heat events occurred from 2000 to 2023 in different boroughs of the city.
WIW	Winter Weather	NYC experiences an average of 27 inches of snowfall and 72 days of sub-freezing temperatures each year. These wintry conditions compromise public safety and prevent the normal day-to-day functioning of infrastructure. Winter weather is especially dangerous for people who work outdoors, homeless populations, people with inadequate home heating, and other vulnerable populations. In a recent extreme example, over 30 inches of snowfall accumulated during the blizzard of 2016, making it one of the largest snowstorms in NYC history. In addition to shutting down City services like the subway, the storm caused moderate storm surge and coastal flooding.

What are Hazard Impacts?

What are Hazard Impacts?

Hazard Impacts represent the potential loss resulting from a hazard across a variety of factors, including mortality loss, morbidity loss, property loss, environmental loss, response costs, and indirect costs. For each factor, understanding impacts should consider two key factors: the consequence of a hazard and the likelihood of that hazard occurring. In theory, the expected loss for a hazard with large economic consequences that occurs rarely (e.g., building damage due to earthquakes) might be comparable to the expected loss for another hazard with smaller economic consequences that occurs more frequently (e.g., snow removal costs from winter storms). Additionally, if each factor can be expressed in a common metric, such as US dollars (USD), evaluating the consequences of events with a range of likelihoods can produce *expected annual impacts,* which allow factors to be aggregated as well as compared across hazards.

However, significant disparities exist between consequence monetization methodologies across factors and hazard types based on data availability and historical interest in hazard-specific risk quantification, leading to results with unequal merit and bias. For instance, FEMA's HAZUS tool can be used to estimate annualized building-level direct physical damages and relocation costs due to flooding, earthquakes, and wind hazards; however, no such tool exists for comparable impacts for extreme heat and winter weather hazards.

How do we quantify them?

To reduce this historical bias, hazard impacts in the URI focus more on the relative magnitude and distribution of impacts across the city, rather than absolute values of losses. To achieve this goal, impacts are quantified at the Census tract level for each relevant factor identified for each hazard (as shown on the next slide). The exact method used for determining the receptor and marginal loss varied significantly based on available data and is described in more detail later in this report. These impacts are then normalized based on the corresponding receptor of the impacts – such as land area, count of buildings, or population counts – to account for differences in the way geographic boundaries are drawn, since some census tracts have larger areas, populations, and building stock than others. Next, these normalized values are grouped in two ways – first by performing a percentile ranking across all other tracts, and then by a k-means clustering approach to assign scores of 1 through 5 that represent a relative ranking of impacts as *very high* (5), *high* (4), *moderate* (3), *low* (2), or *very low* (1).

Tract-level impact percentiles and scores for each factor are then summed and re-ranked to get an overall hazard impact score and percentile. Similarly, these tract-level impacts are summed and re-ranked at the neighborhood scale to get the data shown in the public-facing dashboard.

Hazard Impacts Breakdown

Receptor	Loss Factor	Normalization Factor	Coastal Erosion	Coastal Flooding	Coastal Winds	Earth-quake	Extreme Heat	Winter Weather
Land	Shoreline Loss	Land Area	✓	◦	◦	x	◦	x
	Transportation Losses	Land Area	◦	✓	x	x	x	x
	Tree Services	Land Area	x	◦	✓	◦	x	✓
	Snow Removal	Land Area	x	x	x	x	x	✓
People	Dislocation	Population	x	✓	x	◦	x	x
	Power Loss*	N/A	x	◦	◦	◦	✓	◦
	Injuries*	N/A	x	◦	◦	◦	✓	✓
	Death*	N/A	x	◦	◦	◦	✓	✓
	Income Loss**	Building Count	x	✓	✓	✓	◦	◦
Infra-structure	Structure Damage**	Building Count	◦	✓	✓	✓	x	◦
	Content Damage**	Building Count	◦	✓	✓	✓	x	◦
	Loss of Service**	Building Count	◦	◦	◦	◦	◦	◦

✓	Relevant and considered in URI
◦	Potentially relevant but not considered due to data limitations
x	Likely not relevant or unable to be considered

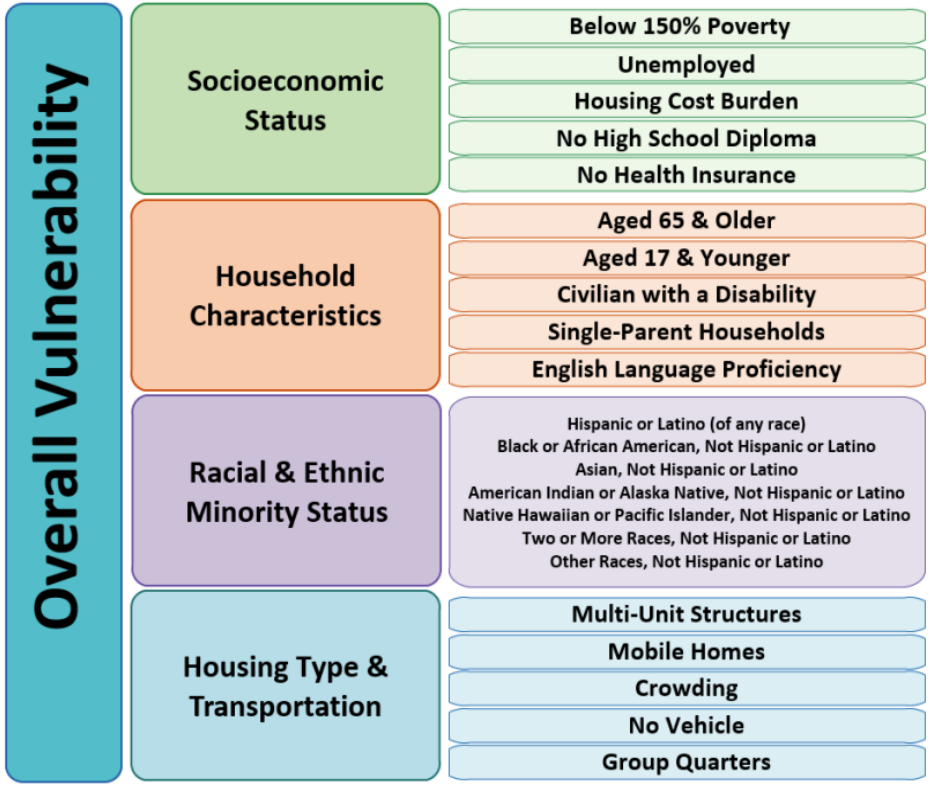
** Power Loss, Injuries, and Death Losses each represent city-wide factors that were scaled to the tract level by population, and therefore were not normalized*

*** HAZUS results point to a lump sum "EconLoss" value, which represents direct physical damages to structures and contents, as well as loss of service and income losses. In the URI, these are all scaled by building count.*

Social Vulnerability

Social vulnerability is an assessment of how demographic factors increase the likelihood of a community experiencing harm during and after a hazard event. The CDC created a Social Vulnerability Index (SVI) to help public health officials and emergency response planners identify and map the communities that will most likely need support before, during, and after a hazardous event. The SVI uses sixteen social factors under four themes (socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation) to provide an overall vulnerability ranking by census tract. All data is from the 2022 American Community Survey (ACS) conducted by the US Census Bureau and provided as a raw count, percentage of total population, and percentile rank. The SVI presents a suitable research-backed method for estimating social vulnerability within New York City.

Like the Resilience Capacity score, when providing scores for larger geographies, the Social Vulnerability scores are calculated as the population weighted average of contributing tracts.



Resilience Capacity

Resilience Capacity is the ability to respond during and recover after a hazard event. In the URI, Resilience Capacity is composed of four categories:

- **Community Capital** – The relationships that exist between individuals and their larger communities, also known as social capital.
- **Mitigation Landscape** – The presence of hazard-mitigating assets and other public investments that reduce the physical impact of hazard events.
- **Response Capacity** – The capabilities and public services that improve residents' ability to respond during and immediately following a hazard event.
- **Recovery Resources** – The economic resources available to residents to assist in physical, social, and financial recovery in the aftermath of a hazard event.

Within each category are several quantifiable factors that are indicative of a community's ability to respond and recover during and after a hazard event. The table on the next slide presents a summary of categories and factors included in the resilience capacity portion of the calculation.

Resilience Capacity Breakdown

Subcomponent	Factor	Coastal Erosion	Coastal Flooding	Coastal Winds	Earthquake	Extreme Heat	Winter Weather
Community Capital	Community Infrastructure	√	√	√	√	√	√
	Education and Outreach	√	√	√	√	√	√
	Place Attachment	√	√	√	√	√	√
	Political Engagement	√	√	√	√	√	√
Mitigation Landscape	Green Infrastructure*	x	x	x	x	x	x
	Mitigation Investments	√	√	√	√	√	√
	Parks with Water Feature	x	x	x	x	√	x
	Vegetative Cover	x	x	x	x	√	x
Recovery Resources	Flood Insurance Coverage	√	√	x	x	x	x
Response Capacity	Air Conditioning in the Home	x	x	x	x	√	x
	Cooling Centers	x	x	x	x	√	x
	Emergency Medical Access	x	√	√	√	√	√
	Evacuation Potential	x	√	x	√	x	x
	Institutional Experience	x	√	√	√	√	√
	Shelter Capacity	x	√	x	x	x	x
	Bikability	x	√	√	√	√	√
	Transit	x	√	√	√	√	√
	Walkability	x	√	√	√	√	√

**Green Infrastructure is expected to be a relevant RCA factor for inland flooding but is not currently captured in URI 2.1*

√	Relevant and considered in URI
x	Likely not relevant or unable to be considered

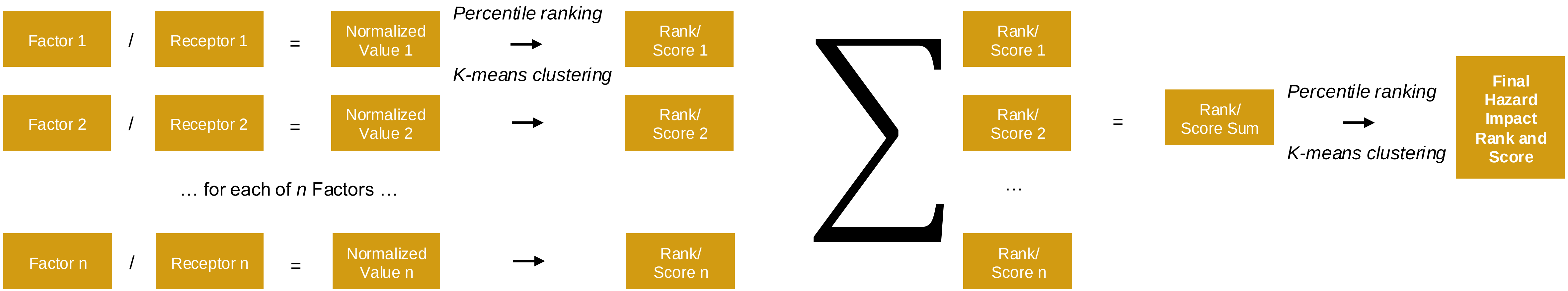
Hazard Impacts Factor Definitions

Hazard Impacts Calculation

As discussed, Hazard Impacts represent the potential loss resulting from a hazard across a variety of factors, including mortality loss, morbidity loss, property loss, environmental loss, response costs, and indirect costs. Detailed methodologies and data sources are outlined in the following slides. To estimate overall Hazard Impacts for a hazard, each relevant factor is divided by the corresponding receptor (land area, population count, building count) to get a normalized value within a tract. These values are then both percentile ranked and scored using a k-means clustering methodology. For all factors that impact a hazard, those ranks and scores are then summed within each tract, re-ranked, and re-scored to get the final hazard impact score for that hazard.

Step 1: Estimate Factor-level Impacts

Step 2: Aggregate Factors to Total Hazard Impact Score:



Coastal Erosion

Receptor	Loss Factor	Description	Data Sources
Land	Shoreline Loss	Coastal erosion rates in the NYC Coastal Erosion Hazard Area (CEHA) regions were estimated based on historic studies that are summarized in the 2019 HMP. According to these studies, the estimated coastal erosion rate is 1.7 ft/yr. in the middle of Rockaway Beach, 1.3 ft/yr. along the Coney Island shoreline, and 1.5 ft/yr. at the Annandale and Oakwood Beach neighborhoods in Staten Island. The erosion rate is zero (stable) in Rockaway East and West as well as South Shore, Staten Island. The total cumulative loss of shoreline was projected by multiplying the historic erosion rate with the shoreline length, and an annual shoreline loss per year was calculated assuming a 100-year time-horizon and a negligible real discount rate. The ecosystem service loss was assigned a value of $8,955/acre/year based on FEMA national guidelines (2022). Because coastal erosion is assumed a slow and gradual process, and structures within the CEHA are minimal, for the purpose of the URI, it was assumed that losses to human and structure impacts were negligible.	Shoreline type and condition provided by NYCEM. Ecosystem service loss value provided by the FEMA Ecosystem Service Value Updates, 2022

Coastal Erosion

Risk = Hazard Impact × Social Vulnerability ÷ Resilience Capacity

Hazard Impact

Receptors

Land

Marginal Loss

Shoreline Loss

Resilience Capacity

Community Capital

Community Infrastructure
Education and Outreach
Place Attachment
Political Engagement

Mitigation Landscape

Mitigation Investments

Response Capacity

None

Recovery Resources

Flood Insurance Coverage

Coastal Storm Flooding

Receptor	Loss Factor	Description	Data Sources
Land	Transportation Losses	The NYC Department of Transportation (DOT) provided an estimate of major storm event expenditures from FY13 to FY21 ranging from \$13M to \$79M per year. The expenditures include the purchase of two ferryboats following Hurricane Sandy. The expenses were annualized and used to approximate losses to major transportation infrastructure.	Data developed by NYC DOT, provided by NYCEM, 2021.
People	Dislocation	The following equation was used to estimate dislocation costs, with assumptions described below: $Dislocation\ Costs = Displacement\ Time \times [(Impacted\ Units \times Lodging\ Per\ Diem\ Rate) + (Dislocated\ Population \times (Food\ Per\ Diem\ Rate - Daily\ cost\ per\ person\ to\ eat\ meals\ at\ home))]$	See below.
		• Dislocated population counts were estimated using the HAZUS coastal flood model (see below).	NYCEM, 2024
		• Each dislocation lasted an average of 30 days	NYCEM, 2019
		• The NYC average of 2.43 persons per household was applied to the dislocated population to get impacted units	US Census, 2020
		• The FY24 local lodging per diem rate is \$257 per night and per diem food rate is \$79	US General Services Administration
		• The daily cost per person to eat meals at home is \$10	FEMA Standard Economic Values Methodology Report (Version 13.0)
Buildings	Damage	Flood damage losses were estimated for each census tract using a HAZUS coastal flood loss model provided by NYCEM. The model provides an estimate of property and contents damage at the census tract level due to coastal flooding from the 1% annual chance (100-year) event defined by FEMA's Preliminary Flood Insurance Rate Map. Future iterations of the URI should include annualized losses from a range of modeled coastal flooding events.	NYCEM, 2024

Coastal Storm Flooding

Risk = **Hazard Impact** × **Social Vulnerability** ÷ **Resilience Capacity**

Hazard Impact

Receptors

- People
- Buildings
- Land

Marginal Loss

- Dislocation
- Building Damage
- Transportation Losses

Resilience Capacity

Community Capital

- Community Infrastructure
- Education and Outreach
- Place Attachment
- Political Engagement

Mitigation Landscape

- Mitigation Investments

Response Capacity

- Institutional Experience
- Emergency Medical Services
- Walkability
- Bikeability
- Public Transit Accessibility
- Shelter Capacity
- Evacuation Potential

Recovery Resources

- Flood Insurance Coverage

Coastal Storm Winds

Receptor	Loss Factor	Description	Data Sources
Buildings	Building Damage	The loss due to wind damage from coastal storms was estimated for each census tract using HAZUS model results for the 1% annual chance (100-year) event provided by NYCEM. The damage assessment includes wind damage to buildings, building contents, inventory, and loss of income. Future iterations of the URI should include annualized losses from a range of modeled wind events.	NYCEM, 2024
Land	Tree Services	The HH&C database was used to obtain the number, type, and latitude and longitude of tree emergency service requests across NYC during coastal storm events. A 48-hour buffer was added to extend the duration of each storm event to capture service calls that were made when the storm ended. Further work could explore adjusted time periods to longer than 48-hours and to base this estimate off existing tree density and age rather than historic impacts. The number of tree service work orders in each census tract was calculated over a period from 2009 to 2023. The cost to provide tree services was assumed to be $3,500 per work order, based on estimated obtained from NYCEM. Using this information, the total loss was calculated and annualized for each tract.	Hazard History and Consequences (HH&C) Database, NYCEM 2024

Coastal Storm Winds

Risk = Hazard Impact × Social Vulnerability ÷ Resilience Capacity

Hazard Impact

Receptors

- Buildings
- Land

Marginal Loss

- Building Damage
- Tree Services

Resilience Capacity

Community Capital

- Community Infrastructure
- Education and Outreach
- Place Attachment
- Political Engagement

Mitigation Landscape

- Mitigation Investments

Response Capacity

- Institutional Experience
- Emergency Medical Services
- Walkability
- Bikeability
- Public Transit Accessibility

Recovery Resources

None

Extreme Heat

Receptor	Loss Factor	Description	Data Sources
People	Mortality	The HH&C dataset was used to determine the average frequency of extreme heat events in each of the five NYC boroughs from 2000-2023. A NYC Department of Health and Mental Hygiene (DOHMH) study analyzed health records from 2013 to 2022 and concluded that an average of 347 excess deaths per year could be attributed to extreme heat events. The frequency of extreme events by borough, total population by borough, and annual deaths across all boroughs were used to estimate an average number of deaths per 1000 people per extreme heat event across the city. This death rate m was then multiplied by the population and annual number of extreme events in each tract to determine the annual number of deaths per tract. Finally, losses were determined using the FEMA-recommended statistical value of life of $13,200,000. Based on this method, the losses were higher in tracts with a higher population and in boroughs with a higher rate of events.	2024 HH&C Database (NYCEM) 2020 ysTRESS Data (provided by DOHMH) FEMA Standard Economic Values Methodology Report (Version 13.0) 2024 heat mortality annual report in NYC | Environment and Health Data Portal
People	Morbidity	Yearly estimates of hospitalizations and emergency room visits without hospitalization were downloaded for each borough from the NYC Environment and Health Data Portal. The yearly estimates were used to calculate the average number of cases per year at the borough level. The number of cases in each borough per year was then distributed to tracts within each borough based on population. For example, if a borough experienced an estimated 20 hospitalizations per year, and a tract within that borough contained 10% of the borough population, then the tract would experience an average of 2 hospitalizations per year. The hospitalizations were valuated as a serious injury with a value of $1,386,000, and the emergency room visits were valuated as a moderate injury with a value of $620,000.	Extreme heat injuries data from the NYC Environment and Health Data Portal. 2020 ECOSTRESS Data (provided by DOHMH) FEMA Standard Economic Values Methodology Report (Version 13.0)

Extreme Heat

Receptor	Loss Factor	Description	Data Sources
People	Power Outages	A 2018 study by DOHMH described the frequency, size, and cause of NYC power outages from 1999 to 2014. The study was used to estimate the annual average number of person-hours of power outage due to extreme heat events. The person days of power outage were evenly distributed throughout the population of the city. According to FEMA, the loss of electrical services has an economic impact of $174 in 2015 dollars per person per day. Aligned with HVI by weighting tract-level expected losses by average surface temperature data from the NASA's ECOSTRESS (2020) to distribute expected death and injury losses from boroughs (higher temperature = higher weight)	2020 Ecostress Data FEMA Standard Economic Values Methodology Report

Extreme Heat

Risk = **Hazard Impact** × **Social Vulnerability** ÷ **Resilience Capacity**

Hazard Impact

Receptors

People

Marginal Loss

Mortality
Morbidity
Power Outages

Resilience Capacity

Community Capital

Community Infrastructure
Education and Outreach
Place Attachment
Political Engagement

Mitigation Landscape

Mitigation Investments
Vegetative Cover
Parks with Water Features

Response Capacity

Institutional Experience
Emergency Medical Services
Walkability
Bikeability
Public Transit Accessibility
Air Conditioning in the Home
Cooling Centers

Recovery Resources

None

Earthquakes

Receptor	Loss Factor	Description	Data Sources
Buildings	Building Damages	NYCEM provided results from a HAZUS model that estimated the loss from a historic magnitude 5.2 earthquake due to building damage, income loss, hospitalization, and displacement for each census tract. Future iterations of the URI should include annualized losses from a range of modeled earthquake events.	NYCEM, 2024

Earthquakes

Risk = Hazard Impact × Social Vulnerability ÷ Resilience Capacity

Hazard Impact

Receptors

Buildings

Marginal Loss

Building Damages

Resilience Capacity

Community Capital

Community Infrastructure
Education and Outreach
Place Attachment
Political Engagement

Mitigation Landscape

Mitigation Investments

Response Capacity

Institutional Experience
Emergency Medical Services
Walkability
Bikeability
Public Transit Accessibility
Evacuation Potential

Recovery Resources

None

Winter Weather

Receptor	Loss Factor	Description	Data Sources
People	Mortality	Yearly estimates of deaths and hospitalizations were downloaded for each borough from the NYC Environment and Health Data Portal. The yearly estimates were used to calculate the average number of cases at the borough level. The cases were distributed to tracts within each borough based on population. The deaths losses were determined using the FEMA-recommended statistical value of life of $13,200,000.	Tables with the number of deaths and hospitalizations due to cold stress from NYC Environment and Health Data Portal. FEMA Standard Economic Values Methodology Report (Version 13.0)
People	Morbidity	Yearly estimates of hospitalizations and emergency room visits without hospitalization were downloaded for each borough from the NYC Environment and Health Data Portal. The yearly estimates were used to calculate the average number of cases at the borough level. The cases were distributed to tracts within each borough based on population. The hospitalizations were valuated as a serious injury with a value of $1,386,000, and the emergency room visits were valuated as a moderate injury with a value of $620,000.	Tables with the number of emergency department visits and hospitalizations due to cold stress from NYC Environment and Health Data Portal. FEMA Standard Economic Values Methodology Report (Version 13.0)

Winter Weather

Receptor	Loss Factor	Description	Data Sources
Land	Snow Removal	The annual average expenses were distributed to census tracts in proportion to the total length of critical snowplow routes for each census tract.	Snow removal budget expenditures from Annual Comprehensive Financial Reports (ACFR) of Office of the New York City Comptroller (through FY23).
Land	Tree Services	The HH&C database was used to obtain the number, type, and latitude and longitude of tree emergency service requests across NYC. The total loss was calculated and annualized for each tract. A 48-hour buffer was added to extend the duration of each storm event to capture service calls that were made when the storm ended. Further work could explore adjusted time periods to longer than 48-hours. The number of tree service work orders in each census tract was calculated over a ten-year period from 2000 to 2023. The cost to provide tree services was assumed to be $3,500 per work order, based on estimated obtained from NYCEM. Using this information, the total loss was calculated and annualized for each tract.	Hazard History and Consequences Database provided by NYCEM, 2024

Winter Weather

Risk = Hazard Impact × Social Vulnerability ÷ Resilience Capacity

Hazard Impact

Receptors
- People
- Land

Marginal Loss
- Mortality
- Morbidity
- Snow Removal
- Tree Services

Resilience Capacity

Community Capital
- Community Infrastructure
- Education and Outreach
- Place Attachment
- Political Engagement

Mitigation Landscape
- Mitigation Investments

Response Capacity
- Institutional Experience
- Emergency Medical Services
- Walkability
- Bikeability
- Public Transit Accessibility

Recovery Resources

None

Resilience Capacity Factor Definitions

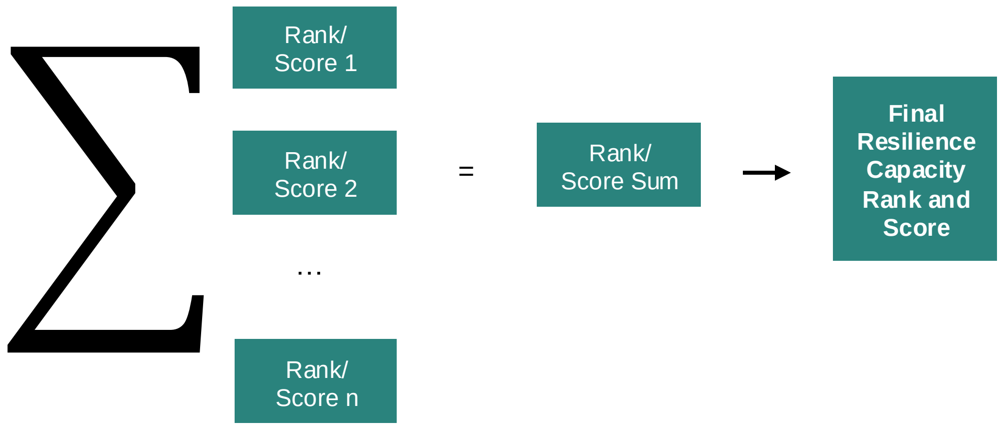
Resilience Capacity Calculation

As mentioned, Resilience Capacity is the ability to respond during and recover after a hazard event and consists of factors across four categories, including community capital, mitigation landscape, recovery resources, and response capacity. Like with Hazard Impacts, the exact methods used for processing raw resilience capacity factor data varied significantly based on available data and is described in the following slides.

After processing raw data, the URI uses k-means clustering to assign each tract a Factor Score from 1 to 5. For each hazard, relevant Factors Scores are summed and re-ranked to generate the final Resilience Capacity score that also ranges from 1 (low resilience capacity) to 5 (high resilience capacity).

When providing scores for larger geographies, such as Neighborhood Tabulation Areas, the Resilience Capacity scores are calculated as the population weighted average of contributing tracts.

Aggregate Factors to get Final Resilience Capacity



Community Capital

Factor	Description	Methodology	Data Sources
Community Infrastructure	Community infrastructure represents the buildings and spaces that provide amenities and services to the public. These spaces, whether publicly or privately operated, facilitate social connections and community ties. In the URI, Community Infrastructure considers the average number of community facilities located within walking distance (½ mile) of residents.	To estimate the average number of facilities located within walking distance of residents within a census tract, a ½ mile buffer was applied to each point of interest and the portion of the tract covered by each intersecting circle was calculated. Adding up the overlapping portions gets results in an average number of facilities.	Point map of Libraries and Cultural Institutions, Senior Centers, Public Elementary and Secondary Schools, and Food Programs and Drop-In Centers (often affiliated with houses of worship) from NYCEM, 2024
Education and Outreach	Education and Outreach from the perspective of emergency management represents the number of Ready NY events held within walking distance (½ mile) of residents.	Same methodology as Community Infrastructure.	Locations of Ready NY events taking place from 2013 to 2023, provided by NYCEM, 2024
Place Attachment	Place attachment describes the social, economic, and emotional bond between a person and a place. People with strong place attachment are less likely to re-locate following a substantial disaster and more likely to have local networks that can support response and recovery.	For the URI, place attachment is measured as the percent of the population who have resided in their current borough for 1 year or more.	2022 5-year American Community Survey data from the US Census Bureau, accessed via the census python library
Political Engagement	Political engagement is indicative of broader community engagement and information access. It can be measured by looking at voter turnout in recent elections.	NYC Votes constructed “voting participation score” for every active voter in the city, ranging from 0–100, based on voter turnout between 2008 and 2018, and averaged those scores to determine a weighted Voter Participation Score for each NYC census tract.	Weighted mean voter participation score from the NYC Campaign Finance Board’s 2019 Voter Analysis

Mitigation Landscape

Factor	Description	Methodology	Data Sources
Green Infrastructure	Projects in NYC's Green Infrastructure Initiative present an alternative approach to improving water quality by integrating "green infrastructure," such as swales and green roofs, with investments to optimize the existing system and to build targeted, cost-effective "grey" or traditional infrastructure. In addition to providing hazard mitigation, green infrastructure can provide ecological and social benefits, including physical and psychological benefits that contribute to community health and resilience. For this factor, the URI considers the density of green infrastructure (GI) projects in and around the census tract.	To calculate the density of GI projects within a census tract, a buffer is used to expand the area of interest to 0.1 miles outside of the census tract. This accounts for an expectation that GI projects provide a benefit to the immediate surrounding neighborhood. Then the total number of projects within the buffered area is divided by the total buffered area to get a final density score in terms of projects per square mile.	Point locations of green infrastructure projects from NYC Department of Environmental Protection, 2024
Mitigation Investments	Mitigation Investments are the financial investments in infrastructure, planning, response, and resource protection that the City has already made to reduce hazard impacts. For the URI, this element considers the combined cost of completed hazard mitigation projects mapped in the Hazard Mitigation Plan, distributed across the estimated impacted areas.	For each hazard, only completed projects relevant to the specific hazard are considered. If projects incorporate multiple locations, cost is distributed equally across points. When estimating impacted area, a ½ mile radius/buffer was applied to project locations (mapped as points, lines, or polygons), to estimate an area of loss avoidance. The Cost per Hazard Addressed is then distributed proportionally, by area, across intersecting tracts. This represents the expectation that projects provide a benefit to the surrounding neighborhood.	Mapped, costed, and completed mitigation projects with existing or completed schedule status, provided by NYCEM, 2024.
Parks with Water Feature	Public spray features can be used by residents (particularly families with young children) to stay cool during extreme heat events. For this factor, the URI considers the average number of spray showers within walking distance of residents.	To estimate the average number of facilities located within walking distance of residents within a census tract, a ½ mile buffer was applied to each point of interest and the portion of the tract covered by each intersecting circle was calculated. Adding up the overlapping portions gets results in an average number of facilities.	Point locations of spray showers from NYC Parks and Recreation, 2023
Vegetative Cover	Vegetative cover is the land covered by trees, grass, or other plants. This area is not covered by a hard surface such as paved roads, sidewalks, or buildings. Vegetative cover tends to reduce temperatures in the immediate area. It can also help with rainwater absorption and flood attenuation.	Zonal statistics were applied to the land cover raster dataset to obtain the total vegetative cover for each census tract.	The Office of Technology and Innovation (2022) developed a 6-in resolution 8-class land cover dataset derived from the 2017 Light Detection and Ranging (LiDAR) data capture

Recovery Resources and Response Capacity

Factor	Description	Methodology	Data Sources
Flood Insurance Coverage	Flood insurance coverage can potentially reduce the financial burden posed by disaster costs.	Flood insurance coverage looks at the percent of housing units that are covered by an active National Flood Insurance Program (NFIP) flood insurance policy.	NFIP Policy locations were provided by NYCEM through FEMA, data valid as of April 2019.
Air Conditioning in the Home	Access to air conditioning in the home significantly reduces the likelihood of heat stress and heat-related illness in the event of an extreme heat event.	For this factor, the URI considers the number of households in an area estimated to have functioning air conditioning, divided by the number of households in the area; expressed as percent.	2023 PUMA-level statistics of air conditioning availability in homes from the New York City Housing and Vacancy Survey, provided by NYC Department of Health and Mental Hygiene
Cooling Centers	A cooling center is a facility, such as a senior center or community center, where people may go to enjoy air-conditioned comfort during a heat emergency. For this factor, the URI considers the average number of cooling centers located within walking distance of residents	Same methodology as Community Infrastructure.	Cooling center locations from the *Cool It! NYC* dataset developed by the NYC Department of Parks and Recreation, 2023
Emergency Medical Access	Emergency medical services considers resident's proximity to hospitals that provide the relevant type of emergency services. For this factor, the URI considers the average distance to the nearest hospital that treats the expected emergency type.	To calculate the average distance a resident would need to travel to find the nearest relevant hospital, the URI calculates distance from the center point of the tract of interest.	Point locations of hospitals, provided by NYCEM, 2024
Evacuation Potential	Evacuation potential indicates the relative ease of evacuating in case of a severe hazard event.	For the URI, evacuation potential measures average distance from the center point of the tract of interest to either a hurricane evacuation center or a hurricane evacuation zone.	Polygon boundaries of hurricane evacuation zones and point locations of hurricane evacuation centers, provided by NYCEM, 2024

Recovery Resources and Response Capacity

Factor	Description	Methodology	Data Sources
Institutional Experience	Institutional Experience represents the amount of experience the city response sector has with respect to different hazards. The baseline assumption is that the city's overall response will be stronger if the city has spent more time responding to that particular hazard in the past. The institutional experience is presumed to be a city-wide characteristic with only one value, per hazard type, for the entire city.	The number of days of EOC activation for each hazard was converted to a score from 1 to 5 based on the number of EOC activation days for each hazard type and influenced by NYCEM subject matter expertise. The score was applied to all tracts.	Activation days were extracted from the 2024 Hazard History and Consequences (HH&C) database maintained by NYCEM.
Shelter Capacity	When a disaster causes evacuations or displacement, shelter capacity is the ability to house those unable to stay in their own homes. To measure shelter capacity of a neighborhood, the URI considers the estimated long-term capacity in nearby NYCEM evacuation shelters, per 1000 tract residents.	Shelter capacity per 1000 residents is estimated based on the assumption that shelters serve all census tracts that touch within a 1-mile radius, and available capacity is allocated proportional to the population served.	Point locations of hurricane evacuation shelters, from NYCEM, 2024
Bikability	Bikeability helps residents access resources and support services when other transportation options may be unavailable. Bike Score, provided by Walk Score, estimates whether an area is good for biking.	To calculate the bike score for each census tract, the URI will consider the Bike Score at the centroid of the census tract. It is calculated on a scale of 0 through 100 by measuring bike infrastructure (lanes, trails, etc.), hills, destinations and road connectivity, and the number of bike commuters.	Balk Score data was downloaded through the Walk Score API in 2024. Data sources contributing to the Bike Score include USGS, Open Street Map, and the U.S. Census.
Transit	In dense urban areas where personal vehicle ownership is low, access to public transportation increases resident mobility and helps residents access resources and critical services.	To calculate the transit score for each census tract, the URI will consider the Transit Score at the centroid of the census tract. Walk Score creates transit scores between 0 and 100 that measure how well a location is served by public transit. These Transit Scores are based on a "usefulness" value assigned to nearby transit routes based on the frequency, type of route (rail, bus, etc.), and distance to the nearest stop on the route.	Transit Score data was downloaded through the Walk Score API in 2024. Data sources contributing to the Transit score include state and local public transportation agencies.
Walkability	In the event of severe weather or natural disaster, the walkability of a neighborhood helps residents access resources and support services when other transportation options fail.	To calculate the walk score for each census tract, the URI will consider the Walk Score at the centroid of the census tract. Walk Score creates scores between 0 and 100 that measures walking distance to amenities and pedestrian friendliness at any location.	Walk Score was downloaded through the Walk Score API in 2024. Data sources contributing to the Walk Score include Google, Factual, Great Schools, Open Street Map, the U.S. Census, Localeze, and places added by the Walk Score user community.