

# Preparing for the Next One: A Socioeconomic Storm Surge Vulnerability Analysis of New York City

## Background

Hurricane Sandy made landfall in New Jersey on October 29, 2012, resulting in historic destruction across the Mid-Atlantic states. It caused \$65 billion in economic damage, making it the fourth costliest hurricane in history to make landfall in the US.

Flooding and strong winds resulted in 71 deaths, including 44 in New York City alone. Rising sea levels and warmer ocean temperatures mean that such storms are likely to be more destructive and dangerous in the future.

Responding to the unprecedented impact of Hurricane Sandy and the potential for future storms to be equally or more destructive, New York City revised its evacuation zones. These evacuation zones are largely based on FEMA's updated storm surge models.

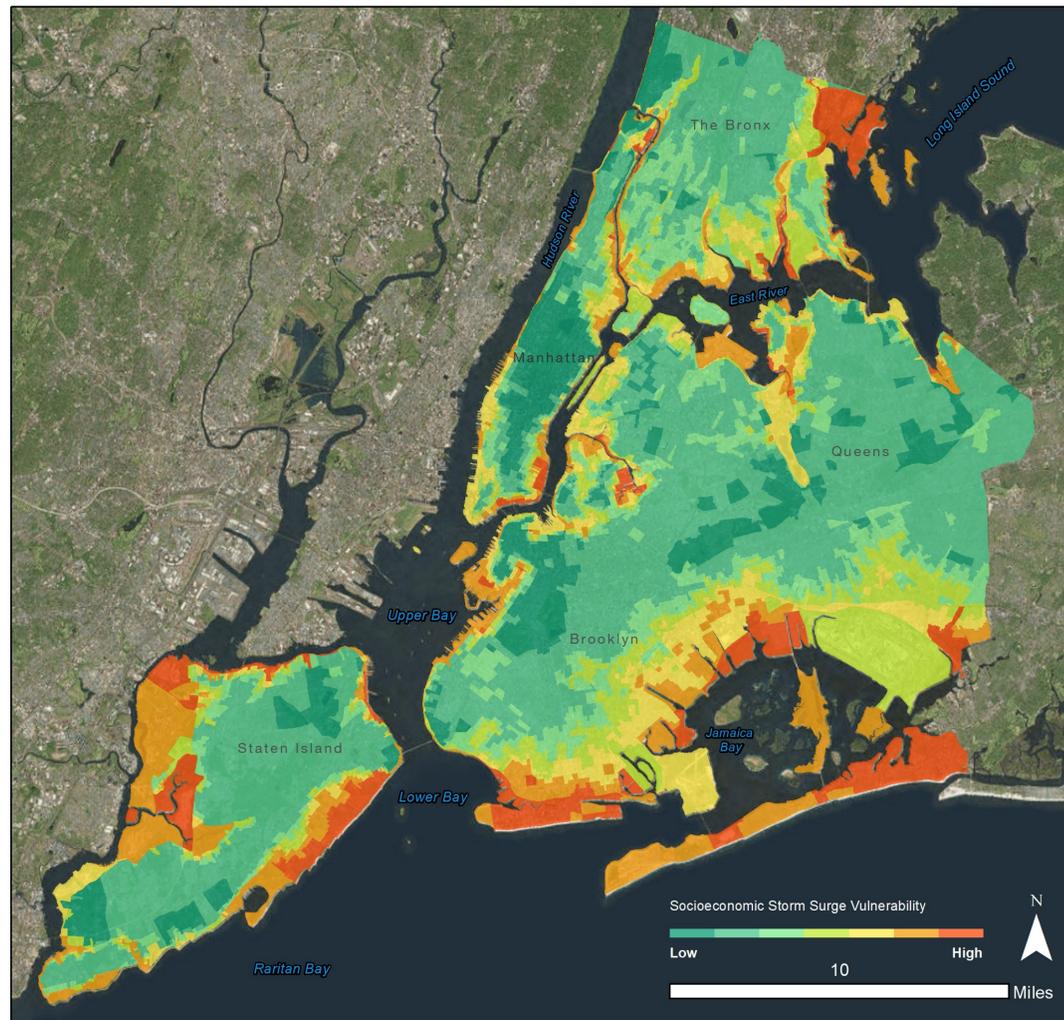
These maps provide a good indication of which areas of the city are physically most vulnerable to flooding from storm surge, but do not consider the social and economic characteristics of local populations—in other words, socioeconomic vulnerability to flooding. This study aims to integrate those factors into a unified socioeconomic storm surge vulnerability GIS.

## Methods

I considered ten socioeconomic factors in creating a combined index of socioeconomic vulnerability to natural disaster:

Variable	Weight
Median Income	25%
Access to a Vehicle	10%
Percent Elderly	5%
Percent Under 18	5%
Population Density	5%
Limited English Households	15%
Percent Non-White Population	5%
Percent With Disability	15%
Educational Attainment	5%
Single Female Householders	10%
<b>Total</b>	<b>100%</b>

## Vulnerability Analysis



Socioeconomic factors were chosen based on their potential to:

- 1. Make evacuation physically or financially difficult**
- 2. Create challenges to rescue efforts or to communicating accurate information, or**
- 3. Reduce post-storm resiliency and recovery.**

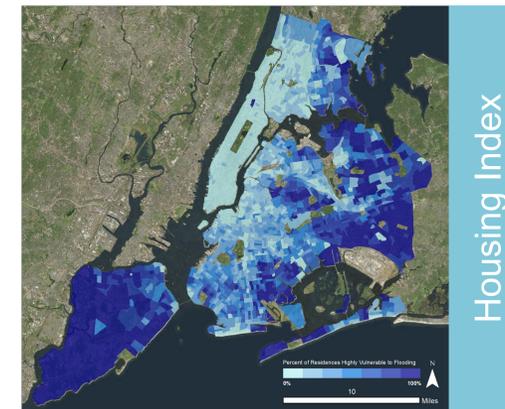
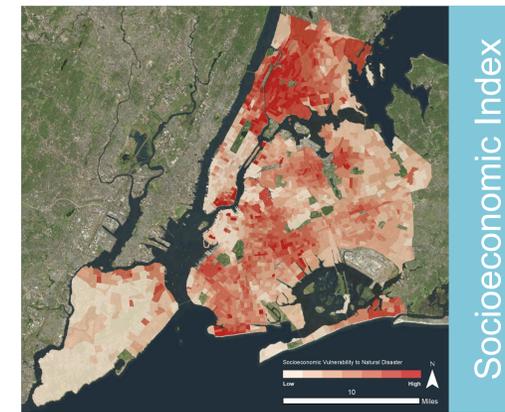
Data were collected by census tract from the 2010 US Census and the 2013-2017 American Community Survey. Census tracts were assigned an index value between one and seven, with one being least vulnerable and seven most. These indices were then combined with a weighted

average into a single index of socioeconomic vulnerability to natural disaster.

To produce the final GIS map, this socioeconomic vulnerability index was combined with a geographical storm surge vulnerability index as well as a housing flood vulnerability index:

Index	Weight
Socioeconomic Vulnerability	35%
Geographic Storm Surge Risk	55%
Vulnerability of Housing to Flooding	10%
<b>Total</b>	<b>100%</b>

The storm surge vulnerability index was derived from New York City's hurricane evacuation zones. The housing flood vulnerability was



calculated by sorting census tracts by the percent of residential structures with two units or fewer. Residents living in these structures are at heightened risk of death or injury due to flooding.

I combined these three indices into a single index of socioeconomic vulnerability to hurricane storm surge using a weighted average. The weights for the different indices were chosen to emphasize socioeconomic risk in storm surge vulnerable areas.

## Conclusions

The final results highlight the areas of New York City most socioeconomically at risk from storm surge. The usefulness of this information lies with the ability to compare areas of similar geographic storm surge risk.

For example, the results indicate that the eastern part of the Rockaway Peninsula is slightly more socioeconomically vulnerable to storm surge than the west, that the Lower East Side of Manhattan is more vulnerable than neighborhoods on the west side of Lower Manhattan, and that Brighton Beach is more vulnerable than other areas of Brooklyn, like Red Hook or Sunset Park. These are areas that potentially warrant greater focus in pre-storm outreach, information, and evacuation efforts and post-storm rescue and relief operations.

### Limitations

There are some limitations to the data used in this analysis. Originally, population in group quarters was to be included as a socioeconomic vulnerability variable. Group quarters refer broadly to institutions such as prisons, psychiatric hospitals, or homeless shelters. Ultimately, this variable could not be included due to census tract size being too large to adequately capture the concentration of these populations.

Many of the socioeconomic variables rely on household census data. Thus, this analysis has little to say directly about the vulnerability of that portion of New York's homeless population not living in shelters, which is estimated to be in the thousands.

Finally, it is important to note that this study represents a relative, not absolute measure of socioeconomic vulnerability, as indices were categorized in relation to the data in other New York City census tracts.