Hurricane Vulnerability in Manhattan

Assessing Geophysical Risk and Social Vulnerability

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Overview

Hurricanes making landfall near New York City have the potential to cause significant interruptions to city operations, given the highly vulnerable tall buildings and bridges, flood-prone underground systems, and critical infrastructure located near the coast. During Hurricane Sandy in 2012, storm surge in some areas of the city reached 13.8 feet to surpass the 10.2-foot record set in 1960. New York Governor Andrew Cuomo estimated the cost of damage from Hurricane Sandy to be more than $42 billion, which included $33 billion to repair housing and infrastructure and $9 billion to protect transit systems and utilities (Kaplan, 2012).

Although these numbers focus on economic impact, the increasing number and intensity of of storms also underscore the need to better understand the human dimensions of vulnerability and risk. Assessments that measure the relative vulneability and coping capacity among communities help guide disaster risk reduction, capacity building efforts, and emergency response priorities (Roy and Blaschke, n.d.). This project analyzes vulnerability at the census tract level in Manhattan based on factors that determine geophysical risk and social vulnerability. Using Geographic Information Systems (GIS) in this type of analysis is effective in its ability to integrate multiple data sources and show a geographic representation of complex data.

Methods

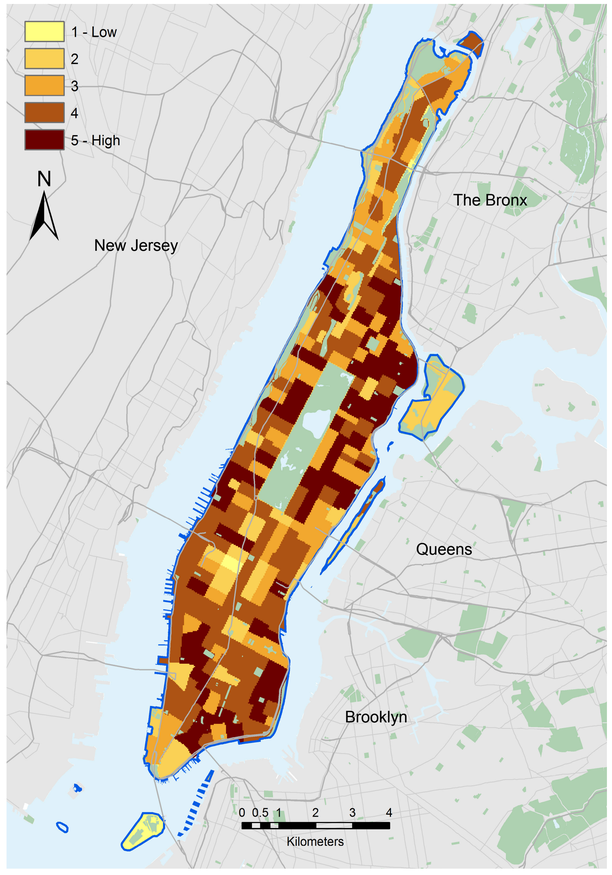
The assessment used a factor analysis to cluster risk and vulnerability indicators according to four theme-based factor groupings. Each census tract received a vulnerability score of 1 to 5 to indicate low to high vulnerability for income and material resources, geophysical risk, lifelines, and age, which were then added to calculate a total vulnerability score. Each grouping was weighted equally in calculating the total score. The score for each factor grouping is the sum of its composite indicators. High percentages for census data, high population density, and high mean distance from lifelines received higher vulnerability scores in the assessment. The mean Euclidean distance to all 3 lifelines was calculated for each census tract to determine the lifeline vulnerability score.

References

Kaplan, T., & Hernandez, R. Cuomo, in Aid Appeal, Cite Broad Reach of Storm. (2012, November 26). *The New York Times*. Retrieved from newyorktimes.com

Roy, D.C., & Blaschke, T. (n.d.). A Grid-Based Approach for Spatial Vulnerability Assessment: A Case Study in Bangladesh. Retrieved from http://ispace.researchstudio.at/sites/ispace.researchstudio.at/files/238_full.pdf

Total Vulnerability



Factor Groupings

Income and Material Resources: Percent of households without no vehicle (2007-2011 American Community Survey 5-year estimate) and percent of the population with poverty status in the 12 months prior to the 2010 census

Geophysical Risk: Percent of census tract area in SLOSH zone and population density per sq-km

Lifelines: Distance from 911 receiving hospitals, distance from hurricane evacuation centers, and distance from subway entrances

Age: Percent of the population < 5 and percent of the population > 65 (2010 census)

Definitions: Sea, Lake, and Overland Surges from Hurricanes (SLOSH) zone data represents projections of vertical storm surge heights for category 1 to 4 storms. 911 receiving hospitals receive patients dispatched by emergency medical services. Hurricane evacuation centers process people who require shelter during a hurricane.

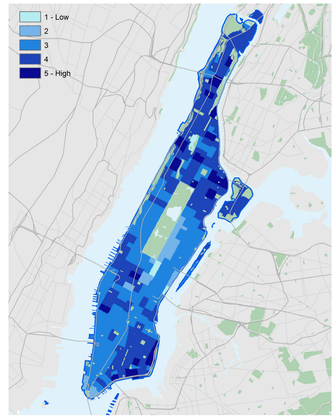
Results

The total vulnerability map aggregates each factor grouping to show the total vulnerability score for each census tract. It shows that vulnerability is high across Manhattan and fairly evenly distributed across the borough, with some high risk clustering in East Harlem near the Bronx. Age-related vulnerability is highest on the east side of Central Park, where 33.5 to 41.6% of the population is either under age 5 or over age 65. The census data shows that it is largely the over 65 population that increases the vulnerability score of this area, as this age group represents between 24.9 and 37.3% of the population in these tracts, while the under 5 group represents between 2.6 and 7.7%. The age map also highlights where nursing homes are located in SLOSH zones. Geophysical risk is highest in East Harlem near the Bronx as well as in the West Village and Tribeca areas, located on the west side Manhattan toward the south. Areas in East Harlem have a high density, with several tracts in this area with densities from 38,181 upward to 83,763 per square kilometer. These dense areas also have several tracts between 40 and 100% covered by a SLOSH zone. Income and material resource vulnerabilities were highest in the Lower East Side, Randall's Island (northeast corner of the main island), and Harlem near the Bronx where there are a number of tracts in which 75 to 89.5% of the population has no vehicle, and where 27.2 to 41.8% of the population reported poverty status within the 12-month period prior to the 2010 census. One tract on the Lower East Side and several tracts in Harlem and Randall's Island have 41 to 87% of the population in poverty status. Randall's Island and the west side of Manhattan below Central Park have a number of tracts with lifeline-related vulnerabilities based on a high mean distance from this critical infrastructure.

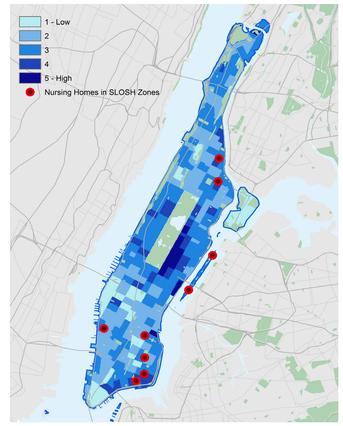
Limitations

There is no common standard for selecting and weighting vulnerability indicators. Data gaps, inaccuracies, and indicator selection influence final measures of vulnerability. In this analysis, indicators for each factor grouping were limited to available data and do not encompass the range of variables that likely determine vulnerability. For instance, the population with disabilities is not available for Manhattan in the most recent census population estimates. Weighting social vulnerability criteria is also largely subjective. Given this constraint, this analysis weighted each factor grouping equally. However, equal rankings are unlikely to represent realities during a hurricane.

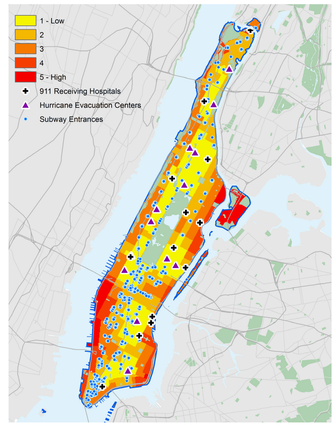
Income and Material Resources



Age



Lifelines



Geophysical Risk