

# An Exploration of Disaster Planning

## Vulnerability Analysis and Shelter Selection of a New York City Evacuation



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 Course: UEP 232 – Intro to GIS – Spring 2010  
 Projected Coordinate System: NAD 1983 StatePlane New York Long Island FIPS 3104 Feet  
 Sources: NYC.gov (Bytes of Big Apple, DoITT, DataMine), Census 2000

### Background

Disaster planning is an essential precaution for every town and city. Being the most populated city in the U.S. and the third most populated city in the world, New York City tops the list of metropolises that calls for an efficient evacuation plan. In the event of a disaster, a well-developed evacuation plan can minimize damages, reduce mortality, and accelerate restoration.



One major aspect of an evacuation plan is an assessment of which areas are most vulnerable to the catastrophes of a disaster. Depending on the type of disaster, different factors take priority. But generally, those who are most vulnerable during a disaster event are those who need the most assistance. By taking specific social vulnerability factors into account, a vulnerability analysis can be devised to determine how at risk an area is.

With a population of over 8.3 million over 305 square miles, it is practically impossible to completely clear out entire New York City in an event of an emergency. Therefore, it is crucial to look at possible locations of evacuation shelters. Evacuation shelters are often multi-purpose facilities such as schools, churches, or community centers. Different factors formulate the selection of shelters. Shelters should be situated in both physically suitable areas (e.g. not in a flood zone) and socially suitable areas (e.g. in areas with high demand). In addition to location, the capacity of shelters is important to consider. The capacity of a shelter should be large enough to accommodate those within proximity who are in need.

This project will take a look at these two aspects of disaster planning: vulnerability and selection of evacuation shelters. Five specific social vulnerability factors were focused on for the vulnerability analysis. For the shelter selection, public schools, private schools, and colleges were considered as potential shelter candidates. This project's aim is not to devise a disaster evacuation plan for NYC. It is very difficult to include all the necessary factors that fall into such an analysis due to availability of data and varying circumstances based on the type of disaster. This goal of this project is to provide insight on how GIS can be valuable and advantageous tool in planning for disasters.

### Methods

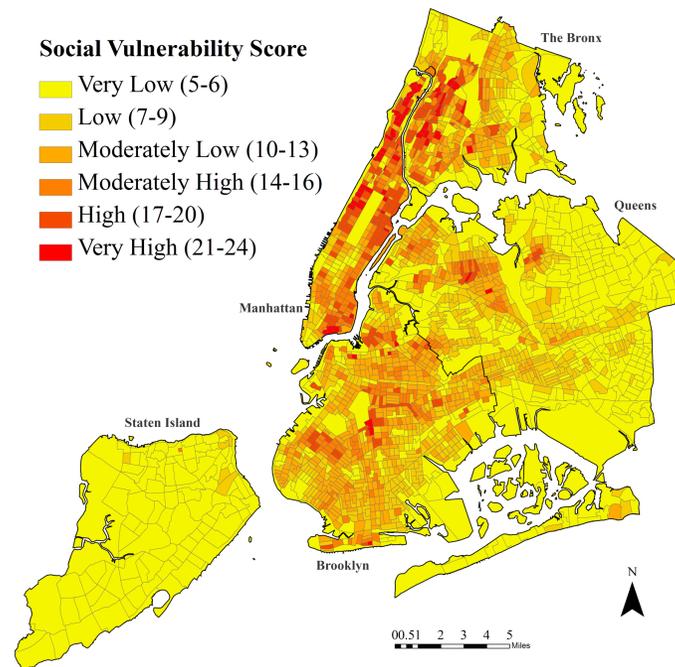
#### Vulnerability Analysis

This process was divided into two steps. The first part of the analysis looked at NYC at census tract level and collecting Census 2000 data for the social vulnerability factors. A map was created for each of the five social vulnerability factors: children under 18, elderly population, population living in high density areas, population in poverty, and households with no vehicles. For each factor, each census tract was assigned a vulnerability score, ranging from 1 to 5, with 5 representing the highest vulnerability.

For the second part of this analysis, the point scores of the five factors were combined, using field calculator, to create a total vulnerability score for each census tract. The total score represents the overall social vulnerability of an area, ranging from very low to very high risk.

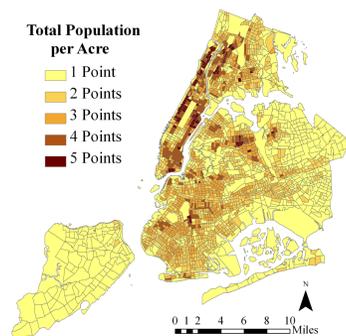
#### Social Vulnerability Score

- Very Low (5-6)
- Low (7-9)
- Moderately Low (10-13)
- Moderately High (14-16)
- High (17-20)
- Very High (21-24)

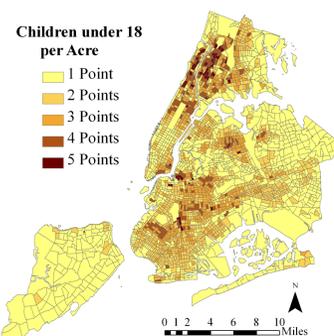


#### Social Vulnerability Factors

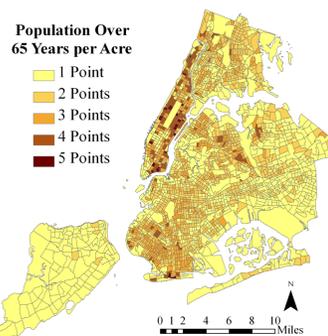
- Total Population per Acre
- 1 Point
  - 2 Points
  - 3 Points
  - 4 Points
  - 5 Points



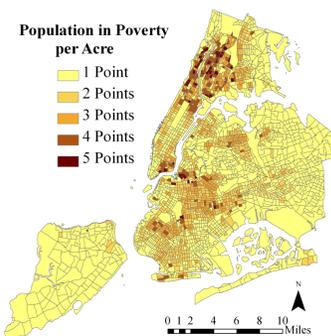
- Children under 18 per Acre
- 1 Point
  - 2 Points
  - 3 Points
  - 4 Points
  - 5 Points



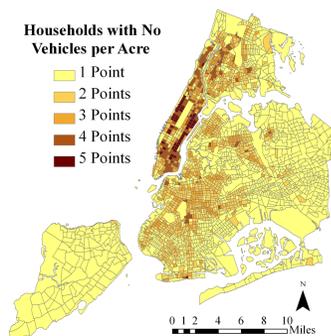
- Population Over 65 Years per Acre
- 1 Point
  - 2 Points
  - 3 Points
  - 4 Points
  - 5 Points



- Population in Poverty per Acre
- 1 Point
  - 2 Points
  - 3 Points
  - 4 Points
  - 5 Points



- Households with No Vehicles per Acre
- 1 Point
  - 2 Points
  - 3 Points
  - 4 Points
  - 5 Points

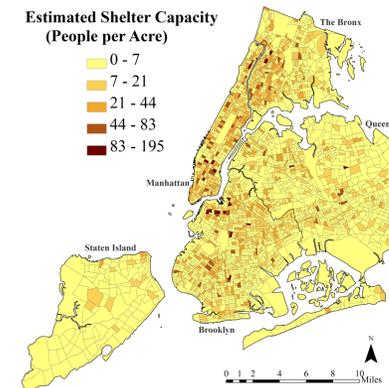


#### Shelter Selection

This part of the project involved looking at "Selected facilities and programs" data from nyc.gov. Of the all of facilities listed, schools were selected out as potential evacuation shelters. The school information (e.g. capacity, location, council district) was then spatially joined to NYC census tracts. This spatial join allowed the capacity (represented as total student enrollment) of the all schools within a census tract to be summed together, resulting in a value that represents the total shelter capacity of the census tract. If the school was used as a shelter, the capacity of the school would be less than total student enrollment due to space demands and time of stay. Therefore, using field calculator, the estimated capacity of the school shelters within a census tract was determined to be 75% of the total shelter capacity.

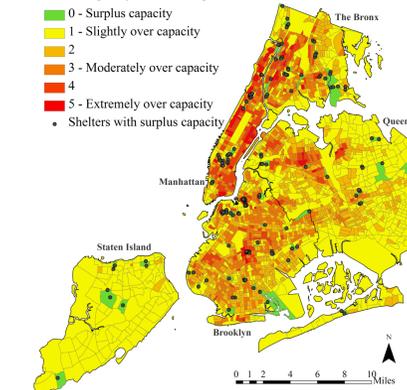
#### Estimated Shelter Capacity (People per Acre)

- 0 - 7
- 7 - 21
- 21 - 44
- 44 - 83
- 83 - 195



#### Estimated Capacity vs. Total Population

- 0 - Surplus capacity
- 1 - Slightly over capacity
- 2
- 3 - Moderately over capacity
- 4
- 5 - Extremely over capacity
- Shelters with surplus capacity

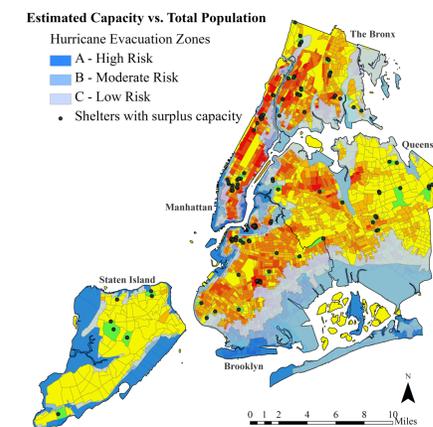


After finding the estimated capacity of each census tract, estimated capacity was subtracted from total population using field calculator. This depicted how well the capacity of each census tract accommodates its population, if the total population was to retreat to evacuation shelters. This also showed the census tract with surplus capacity and the shelters (schools) in these areas were selected out.

To show a further selection of shelters, hurricane evacuation zones were mapped over the Estimated Capacity vs. Total Population map. Shelters that fell within these zones were deemed unsuitable and selected out. Shelters that remain are those outside of the hurricane evacuation zone and with excess capacity.

#### Estimated Capacity vs. Total Population

- Hurricane Evacuation Zones
- A - High Risk
  - B - Moderate Risk
  - C - Low Risk
  - Shelters with surplus capacity



### Results and Reflections

The vulnerability analysis shows that vulnerability varies throughout the entire city. Manhattan and the Bronx are the two counties that have the most vulnerable census tracts in an event of an emergency. In disaster planning, these areas should be given more priority consideration because its residents are at very high risk. Again, this analysis was based on five social factors. In reality, there may be more social factors to be accounted for as well as other elements such as access to major roads, physical features of the city, proximity to facilities and resources, etc. Also, each factor may not be weighted equally like it was in this project, which could provide a more accurate score of vulnerability.

In the selection of shelters, capacity was the major determinant. In this project, estimating capacity was relatively simple since it was just taking into account a portion (75%) of the total of enrollment of students. In actuality, the capacity of a school or any shelter facility is more difficult to formulate. A school's capacity for housing evacuees is much different that is capacity to hold classes for students. Time of stay, amount of space, necessary equipment and furniture are a few elements that need to be considered.

The shelter selection narrowed down 2479 schools and colleges to 156 potential shelters. For this project, these schools qualify as shelters because it meets two requirements.

Firstly, it is located in a census tract where the total capacity of the schools exceeds the total population. This means these schools have the potential to house more people than just the residents of the census tract. Secondly, the school falls outside hurricane evacuation zones, which means the school is accessible in the event of a severe hurricane and a call for evacuation.

In reality, this project has only skimmed the surface in shelter selection. In actual disaster planning, many more facilities would be considered as shelters such as churches, community centers, healthcare facilities. Proximity of these shelters to other resources like police stations, fire stations, hospitals, and major roads would be taken into consideration. The location of shelters can vary according to the type of disaster (e.g. hurricane evacuation shelters would be situated a certain distance from the coast). A vulnerability analysis could also be included as a component in determining shelter locations. Further research on potential disasters, a greater understanding of the city and its features, and the consideration of more social and physical factors would provide more accurate analyses which would lead to efficient evacuation procedures.