Boston Area Hurricane Inundation Risk

Minority Populations Vulnerability Analysis

Introduction

In this vulnerability analysis, we researched the risk of flooding from hurricane inundations in the Greater Boston Area in order to explore whether the racial makeup of an area correlates with inundation risk.

As climate change causes more frequent extreme weather events, Boston is more likely to see serious damage from hurricanes. Due to sea level rise caused by climate change, coastal flooding will become significantly more common, especially in cities such as Boston that are more exposed to the ocean (Kirshen 2007). As flood-causing events like hurricanes become more frequent and extreme, the preparations that we currently have in place will likely be insufficient (Knowlton 2014).

The effects of climate change have historically and disproportionately fallen on the shoulders of underserved populations. Boston is a city with high racial segregation (Tucker 2019), and it is critical that we study and recognize which populations are the most vulnerable to climate change-related damage, so that resources can be best directed towards mitigation and adaptation. Boston's public school system exemplifies the segregation that is endemic in Boston; 86% of students in the Boston Public Schools are non-white (BPS, 2019). We deepened our analysis by exploring possible correlation between public schools in the Boston Area and the risk of hurricane inundation to the areas where the public schools are located.

The spatial question which we aimed to answer was whether areas with a high minority population are more likely to be at risk for hurricane inundation than areas without a high minority population.

Methodology

ArcMap 10.7 was utilized for our analysis. For the Hurricane Inundation Zones layer, we selected by attribute for Hurricane category less than or equal to 3. We then created a new layer from the selection to produce the High Inundation Risk layer. Then, we used select by location for where the Environmental Justice layer intersects with the High Inundation Risk layer. We created a new layer from the selection to create the Environmental Justice High Inundation Risk layer. We then used select by location: tl 2010 block groups layer contains Environmental Justice layer. We inverted this selection, and then proceeded to create a new layer from the selection to produce the tl 2010 non EJ layer. We then selected by location for where the tl 2010 non EJ layer has centroid in the high inundation risk layer. We created a new layer from the selection to produce the tl 2010 non EJ high risk layer.

For the schools layer, we used select by attribute to select for Public Elementary Schools or Public Secondary Schools.

We created a new layer from the selection to produce the Public Schools layer. We then used select by location for which the Public Schools layer is within the High Inundation Risk layer. Next, we created a new layer from the selection to produce the Public Schools High Risk layer. For the Environmental Justice High Inundation Risk layer, we selected by attribute such that percent minority > 75%. Then, we used select by location for where Public Schools High Risk are within selected area of Environmental Justice High Inundation risk layer. We created a new layer from this selection to produce the Public Schools High Risk over 75% layer.

For the Environmental Justice High Inundation Risk layer, we used select by attribute for which percent minority <= 75% and percent minority > 50%. We next used select by location for where Public Schools High Risk are within the selected area of Environmental Justice High Inundation Risk layer. Then, we created a new layer from the selection to create Public Schools High Risk 50 to 75% layer. We next selected by attribute for percent minority <= 50% and percent minority > 25% from the Environmental Justice High Inundation Risk layer. Then, we used select by location for where Public Schools High Risk are within the selected area of Environmental Justice High Inundation Risk layer. We created a new layer from the selection to create Public schools High Risk 25 to 50% layer. Then, we selected by attribute for percent minority <= 25% from the Environmental Justice High Inundation Risk layer. We next selected by location for where Public Schools High Risk are within the selected area of the Environmental Justice High Inundation Risk layer. Then, we created a new layer from the selection to produce the Public Schools High Risk under 25% layer. Then, we used select by location such that Public Schools High Risk are within tl 2010 non EJ high risk layer. Finally, we created a new layer from the selection to produce the Public Schools non EJ high risk layer.

Results

Racial Makeup of Boston Areas at High Risk for Hurricane Inundation

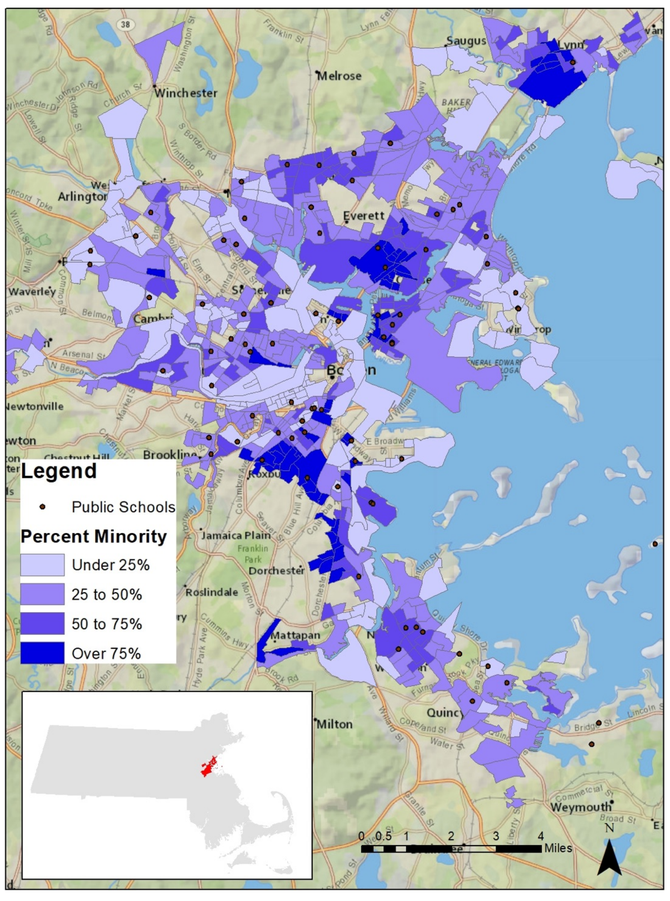

Figure 1. Racial Makeup of Boston Areas at High Risk for Hurricane Inundation

Racial Makeup of Boston-Area Public Schools at High Risk for Hurricane Inundation

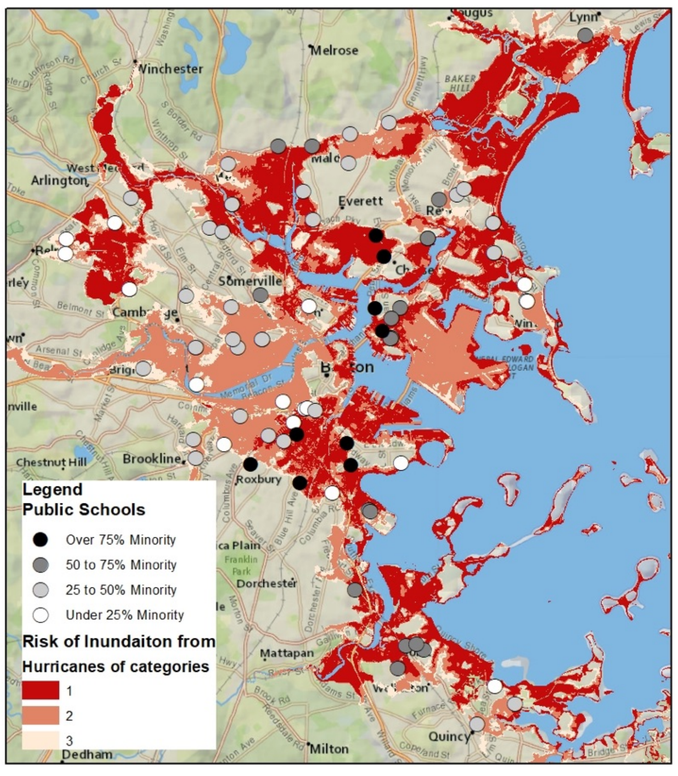

Figure 2. Racial Makeup of Boston-Area Public Schools at High Risk for Hurricane Inundation

Cartographers: Grace Abe and Maya Vishwanath
Projection: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001
Date: May 5 2020

Table 1. Racial Makeup in High Risk Areas

Percent Minority Population	Number of Block Groups
Under 25%	268
25%-50%	278
50%-75%	122
Above 75%	67

Table 2. Public Schools and Racial Makeup in High Risk Areas

Percent Minority Population	Number of Public Schools
Under 25%	23
25%-50%	35
50%-75%	20
Above 75%	10

Table 3. Racial Makeup of Schools at Highest Inundation Risk

Percent Minority Population	Number of Schools
Under 25%	4
25%-50%	5
50%-75%	9
Above 75%	5

We defined High Risk Areas to be those that would be inundated by hurricanes of category 1 through 3; there were 735 such block groups (Figure 1). Massachusetts' Executive Office of Energy and Environmental Affairs defines an area with a minority population of greater than 25% to be an Environmental Justice Population. We found that 467 block groups from the High Risk Areas had minority populations of 25% or higher (and are therefore classified as Environmental Justice Populations), while 268 block groups were made up of under 25% minority populations (Table 1).

We further found that of the 88 public schools that fall within the High Risk Areas, 65 are in areas with over 25% minority populations, while only 23 public schools were in areas made up of under 25% minority populations (Table 2).

We defined Highest Inundation Risk to be areas that would be inundated by a Category 1 hurricane. Table 3 describes the racial makeup of the schools that would be inundated by a Category 1 hurricane (there were 23 such schools). We found that 19 of the 23 public schools in areas of Highest Inundation Risk were also in areas where racial minority groups constituted 25% or greater of the population.

Discussion

Boston areas most at risk for inundation from hurricanes are more likely to have a higher minority population. Boston Public Schools that are at a higher risk for hurricane inundation are more likely to be in areas with a high minority population. Therefore, as climate change makes hurricanes more frequent, public schools in higher minority population areas are more likely to experience flooding. Not only does this endanger these students, but it also severely disrupts their schooling, as schools that are inundated by hurricanes would likely have to close for extended periods of time. This puts minority students at a further disadvantage. In our research prior to conducting our analysis, we saw that Boston is very highly segregated with a high percentage of minority students in its public schools (BPS 2019), and that the city will likely face severe damage due to extreme weather events induced by climate change (Kirshen 2007). Our analysis revealed, as we had hypothesized, that the areas with the highest minority populations are also the areas that will face the most acute damage from hurricanes.

One limitation of our data is that, although both the TIGER/Line block groups and the Environmental Justice block groups are from the 2010 US Census, they are not identical, which may have caused inaccuracies in our map. Another limitation is, although the racial makeup of public schools is similar to that of the area in which they are situated, they are not the exact same. Our analysis is also limited because we analyze based on number of block groups with different percent minority populations in high risk areas, and not the actual population size in high risk areas.

We hope to raise awareness of the fact that the effects of climate change often fall disproportionately on the shoulders of minority populations. These results could potentially be used to help direct resources to help lessen damage to the populations most vulnerable to the effects of climate change. For future analysis, we are interested in looking at infrastructure age and quality in relation to minority populations and hurricane inundation risk. We are also interested in examining the potential consequences of the fact that a large proportion of public schools at the highest risk for hurricane inundation have large minority populations; how will school closures due to flooding impact the learning and education of these students?

Data Sources

2010 U.S. Census Environmental Justice Populations, December 11 2012, Executive Office of Energy and Environmental Affairs
Hurricane Surge Inundation Zones, October 2013, U.S. Army Corps of Engineers, New England District
Massachusetts Schools (Pre-K through High School), June 3 2019, MassGIS
2010 Tiger/Line Shapefiles: Block Groups, 2010, US Census Bureau, Geography Division
Service Layer Credits: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

References

Kirshen, P., Watson, C., Douglas, E., Gontz, A., Lee, J., & Tian, Y. (2007, December 4). Coastal flooding in the Northeastern United States due to climate change. Retrieved March 4, 2020, from https://link.springer.com/content/pdf/10.1007/s11027-007-9130-5.pdf

Knowlton, K., & Rotkin-Ellman, M. (2014). Preparing for climate change: lessons for coastal cities from Hurricane Sandy. *Natural Resources Defense Council Web site*. Retrieved March 4, 2020 from https://www.nrdc.org/file/3911/download?token=ft_PoPCN

Tucker, R. (2019, February 8). Examining Racial Segregation in Boston at Different Geographic Scales. Retrieved April 22, 2020, from https://cssh.northeastern.edu/bostonarearesearchinitiative/2019/02/08/examining-racial-segregation-in-boston-at-different-geographic-scales/#_ftn1

BPS Data and Reports / Facts and Figures. (2019, December). Retrieved April 22, 2020, from https://www.bostonpublicschools.org/domain/238