Immigrants In NYC And Flood Exposure:

An Investigative Data Exploration

By Fiona Dubay

Introduction

In 2021, the remnants of Hurricane Ida rained down upon NYC, causing record inland flash flooding in many parts of the city and taking the lives of 13 people (Newman et al. 2021). Eleven of those deaths took place in basement residences across Queens. It was the severity of precipitation that caused torrents of water to flow so quickly that residents didn't have time to escape. Hurricane Ida set a new rainfall record for hourly precipitation with 3.24 inches of rain recorded in a single hour at Newark Airport (Plumer 2021).

Nearly all of the people who lost their lives in basement apartments were immigrants, and many of them did not speak English (Yam and Venkatraman 2021). According to the New York City Department of Buildings, five of the six below-ground dwellings were never legally cleared to be apartments. All six were undergoing law enforcement investigations in 2021 (Yam and Venkatraman 2021). Unlawful conversions are often the only affordable option for many New Yorkers. Unfortunately, much media attention after Ida became focused on the cracking down of illegal basement apartments. But the reality of an illegal apartment citation means that tenants would suddenly have to move, leaving them no place to go. The average monthly rent for an apartment in Queens is currently $2,925. The damage wrought by Ida's remnants is not necessarily new to NYC residents, but its severity does remind us to ask questions about who endures the most exposure to flooding.

"Roxanna Florentino looked at the damage in the basement of the building where she lives in Brooklyn on Thursday. Her neighbor, Roberto Bravo, died there on Wednesday night as surging waters poured in." (McKinley et al. 2021)

Background

Coastal flooding

Possibly the most well-known coastal flooding event in recent history in the NYC area was extratropical storm Sandy (colloquially referred to as Hurricane Sandy), which hit the city of New York in October of 2012. Sandy caused an estimated $50 billion of damage, destroyed at least 650,000 houses in the U.S., and took the lives of 43 people in NYC (Reed et al. 2015). The devastation from tropical storms is largely from their associated storm surges. A storm surge is an anomalously high tide driven by wind patterns, storm track, and coastal geomorphology (Reed et al. 2015). Typically, the larger the tropical storm, the higher the storm surge.

Pluvial flooding

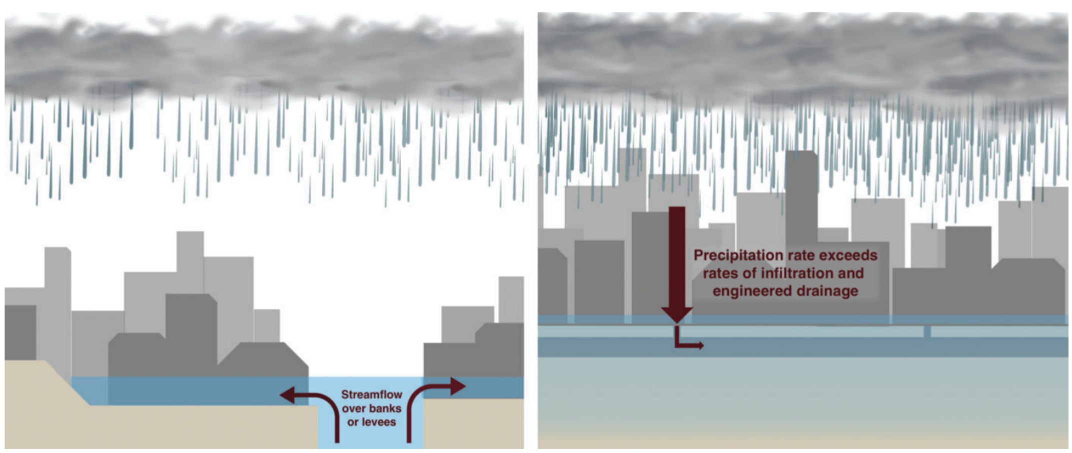
Pluvial flooding is specifically defined by previous research as rain-driven ponding or overland flow that results from the exceedance of natural or engineered drainage capacity (Rosenzweig et al. 2018, Carter et al. 2015, Falconer et al. 2009). Pluvial flooding is challenging to monitor and even harder to record, especially in urban areas. This is unfortunate because pluvial flooding is often a critical issue in urban water management. Most modern cities are vulnerable to pluvial flooding due to aging stormwater infrastructure systems and rapid land cover change from accelerating urban development. Climate change is expected to increase the intensity and frequency of precipitation, therefore also exacerbating the danger and damage caused by urban pluvial flooding and increasing the need for a better understanding of how urban citizens can be at risk.

Pluvial flooding is currently excluded from the US National Flood Insurance Program (NFIP). Because NFIP does not cover it, it is also excluded from subsidized insurance coverage and flood hazard mapping in national flood management projects (Rosenzweig et al. 2018). Unlike coastal flooding, there are no mandates that require the purchasing of flood insurance in areas that are vulnerable to pluvial flooding. This leaves many at-risk individuals without warning for the damages they may face from pluvial flooding. The Federal Emergency Management Agency's (FEMA) Flood Hazard Layer in NYC–the area within which all property owners are federally mandated to buy flood insurance–spans the city's coastline, and does not account for areas that have historically flooded with rainfall events. While pluvial flood damages are not technically covered by subsidized flood insurance, the owners of insured buildings could still place insurance claims for damages made during pluvial flood events.

Fluvial & groundwater flooding

Fluvial flooding occurs when water within streams, rivers, or other water bodies overflows its banks, inundating the adjacent floodplain (Rosenzweig et al. 2018). Urban development in the city has covered the vast majority of natural stream beds that previously existed, removing most of the risk of fluvial flooding. Interestingly, fluvial flooding hazard areas within NYC are included in FEMA's flood hazard area that mandates the purchasing of flood insurance. However, these covered stream channels often remain topographically. These valleys can create additional pluvial flood hazards during large precipitation events when overland flow carries rainwater to the previous locale of the streambed.

Currently, data on groundwater flooding in NYC are extremely limited. Groundwater emergence, or groundwater flooding, occurs when the natural water table rises above the ground surface. The modeling of groundwater flooding requires a massive amount of data on subsurface material. For the sake of simplicity, this data exploration will not include fluvial and groundwater flooding.



"Fluvial (left) versus pluvial (right) flooding. Fluvial flooding occurs when water routed by streams, rivers or equivalent water bodies overflows its banks, inundating the adjacent floodplain area. Pluvial flooding occurs when precipitation rates exceed the infiltration capacity of soils and the drainage capacity of stormwater infrastructure, resulting in ponding and overland flow. " (Rosenzweig et al. 2018)

Research Question

The driving question of this project is – *compared to native-born* NYC *residents, are immigrants more or less exposed to pluvial and coastal flood risk?*

Methods

Demographic data

The American Community Survey (ACS) replaced the long-form U.S. decennial census in 2010 as the primary source of population information. The ACS is a high-frequency survey, meaning that data collectors constantly measure the population using small monthly samples. It's one of the most used large sources of demographic data for cartographers, geographers, and anyone else attempting to spatially visualize America (Spielman et al. 2014). This study uses the most recent five-year ACS survey, which includes the years 2017-2021.

The ACS contains information on citizenship status as well as date of birth. The specific attribute 'Allocation of Citizenship Status' is used for this study, as it employs several options regarding place of birth. One of the options involves an 'allocated' or 'not allocated' notation, which, in previous years, was recorded as 'imputed' or 'not imputed.' It's unclear how the ACS allocates birthplace when not provided by the responder, as documentation on this process was not readily available through the ACS website or data dictionaries.

The ACS is also a preferential data source for demographic information because it is available on many geographic levels. The level used for this study is census block groups, the size of which are chosen to all contain relatively the same population. Physically smaller census block groups contain a higher density of people than larger ones.

Flooding data

FEMA's 2015 preliminary flood hazard area for NYC is published in shapefile format by the NYC Planning Department and is used as a representation of coastal flood risk, as well as fluvial flood risk. Available on NYC OpenData are NYC stormwater flood maps of varying severity. Some layers include Sea Level Rise (SLR) as estimated by the New York City Panel on Climate Change (NPCC) in previous reports. The 'Extreme Stormwater Flood with 2080 SLR' is used for this study because the rainfall intensity closely matches that of Ida's rainfall. Adding the

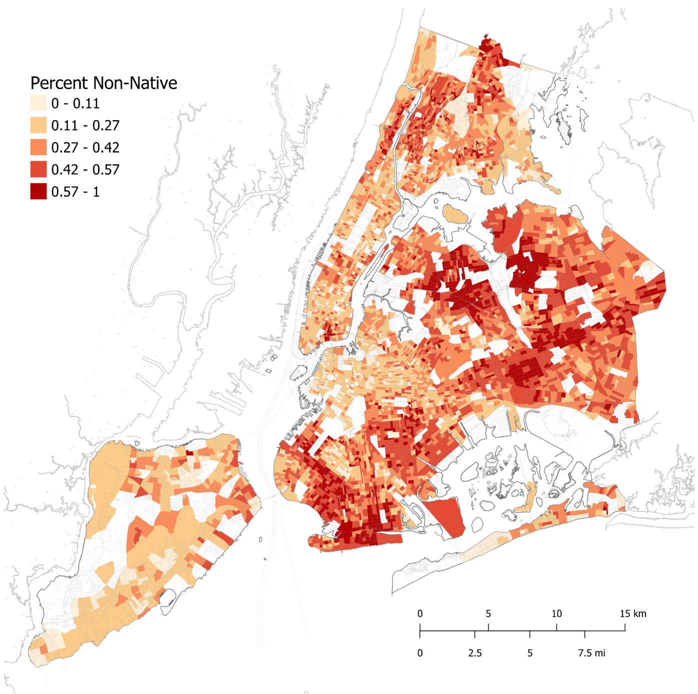
SLR expands the flood hazard layer in the coastal area of the city, but not inland, meaning this shapefile can still be used to represent inland flooding in a pluvial flood event. This layer is also preferential because it includes impacts of potential blocked storm drains and outfalls, which are real issues that already exacerbate pluvial flooding in urban areas.

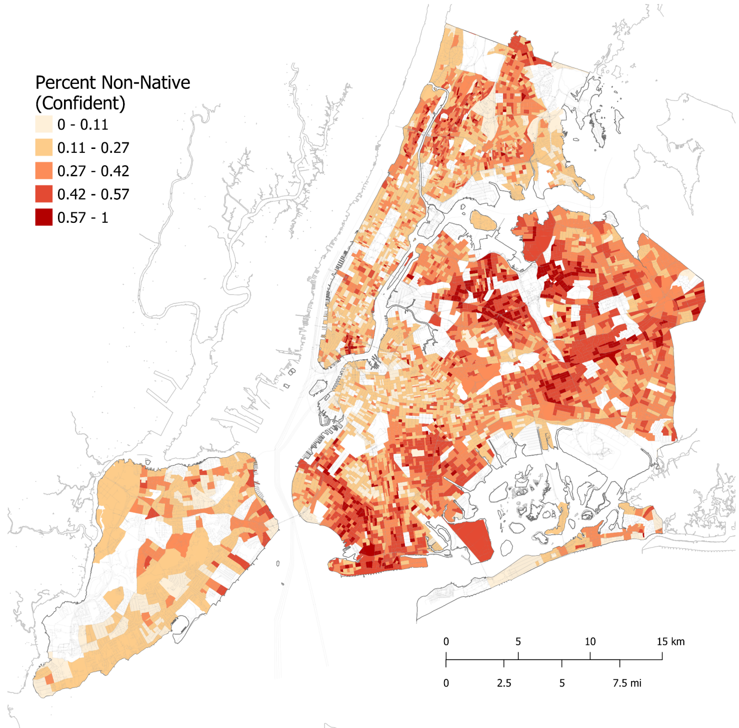
Analyses

The ACS provides counts for attributes, but not percentages. The first step is to normalize each attribute of interest by population. For each census block group, the following is performed: a / N = p (where a represents the attribute count of interest, N represents the total population of the census block group, and p represents the resulting percentage of interest). This normalization is done to the whole dataset at once using the Pandas library within Python. Percentages are then mapped onto the NYC outline using QGIS. Mean and median values for attributes of interest are recorded on a city-wide scale.

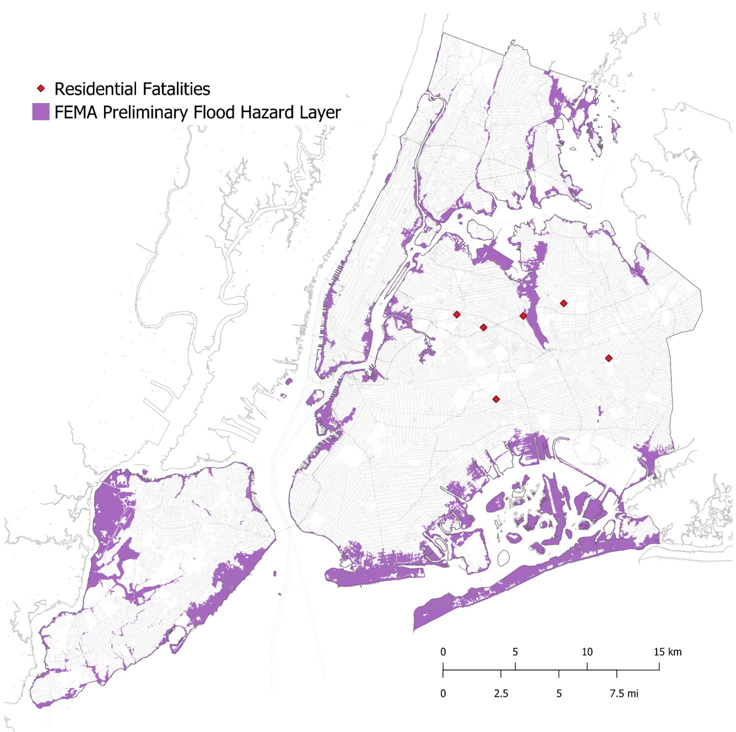
A vector clipping algorithm is used to refine the demographic visualization to the areas of interest. The ACS vector layer is clipped using the features of both the FEMA Preliminary Flood Hazard layer and the NYC Stormwater Extreme layer as overlays. Mean and median values for attributes of interest are recorded on a city-wide scale for both newly clipped layers. Mean and median values are then compared.

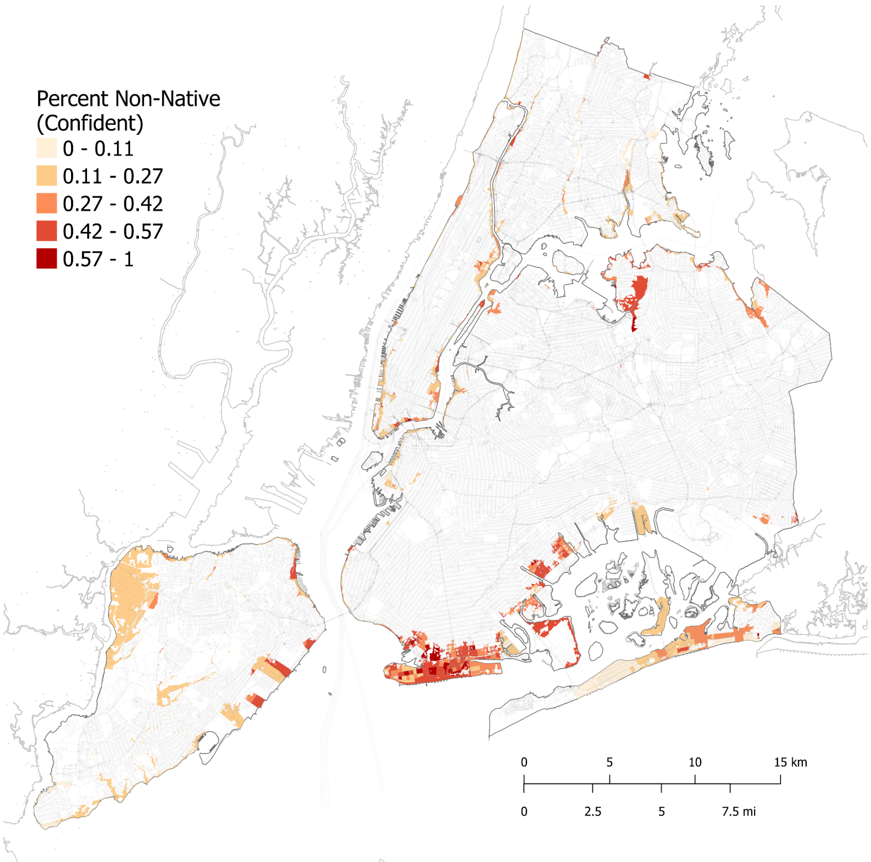
Results and Figures





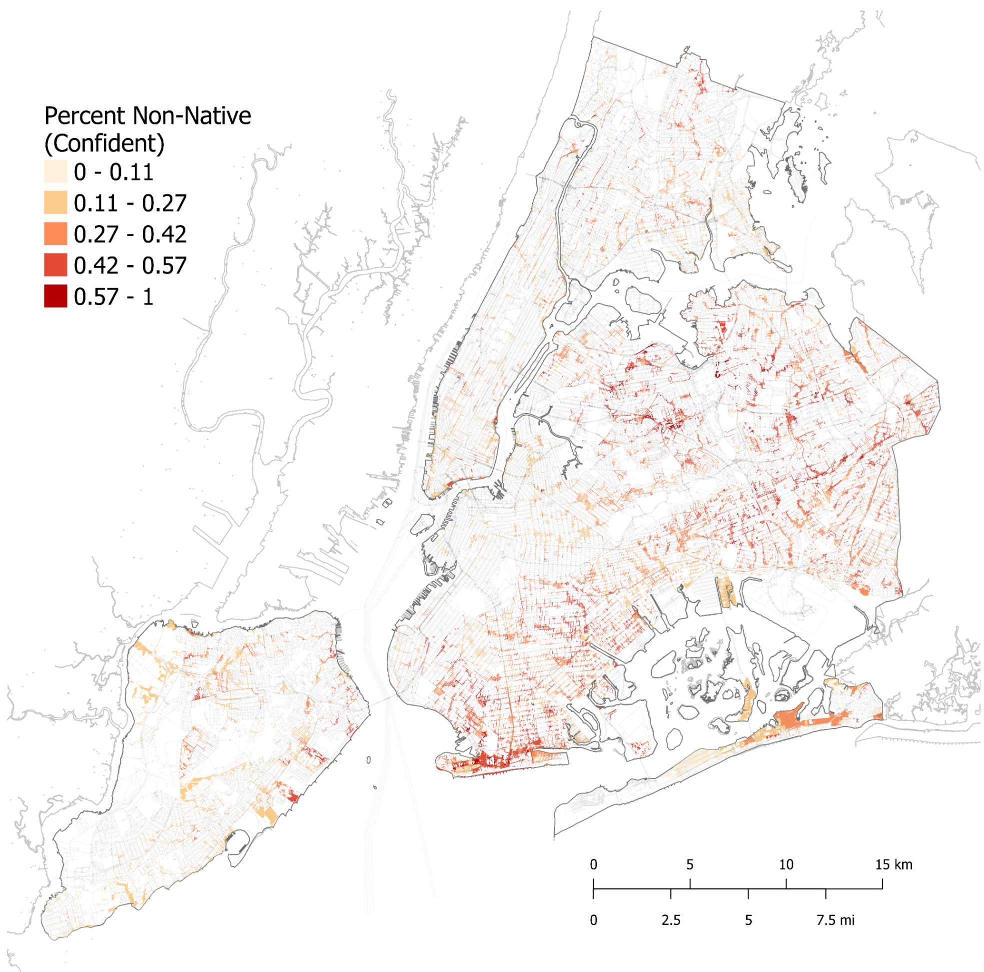
The distribution of foreign-born residents in NYC is, based on this visualization, concentrated in the boroughs of Queens, Brooklyn, and to a lesser extent, the Bronx.





Census block groups colored by percent of the population that is foreign-born, clipped to the outline of the FEMA NFIP Preliminary Flood Hazard Area.

Census block groups colored by percent of the population that is foreign-born, clipped to the outline of the NYC Stormwater Extreme flooding scenario, with 2050 SLR.



	All of NYC	FEMA Flood Hazard Layer	NYC Stormwater Extreme
Mean Percentage Non-Native of Included Census Block Groups	31.503%	27.776%	31.779%
Median Percentage Non-Native of Included Census Block Groups	30.382%	24.985%	30.671%

Discussion

The average percentage of NYC census block groups that are foreign-born (not imputed/allocated) according to the ACS is 31.503%. After clipping the NYC census block group layer to just the block groups that come in contact with the FEMA flood hazard layer, that average percentage goes down to 27.776%. When clipping with the NYC Stormwater Extreme layer that represents pluvial flooding, that percentage goes up to 31.779%. Median values follow the same pattern. This implies two potential takeaways: 1.) the population of New Yorkers who live within the FEMA Flood Hazard Area contains a lower-than-average amount of immigrants and 2.) the population of New Yorkers who live within the NYC Stormwater Extreme boundary contains a higher-than-average amount of immigrants. However, the difference in these values is so small that it is likely insignificant. On top of that, the data used in this study might not even be reliable enough to make any conclusions, no matter how significant.

Issues with data uncertainty

The ACS is a sample survey, which means it is not a complete enumeration and does not perfectly measure the population. Because of this, there exists sample-to-sample variability within the dataset. Taking two samples from the same population would yield different estimates of any given characteristic. The ACS provides a margin of error for each given variable. This number represents the variability that could be expected if a different sample of the given population had been chosen, and is referred to as *sampling error* (Spielman et al. 2014).

Another area for improvement with sample data is response failure. Only 65% of people originally contacted by the ACS complete the survey (Spielman et al. 2014). Some groups are more likely to respond than others. Differential response rates are controlled for by weighting certain responses over others. Each completed survey is assigned a weight that is chosen based on estimates of how likely that group is to respond (Spielman et al. 2014). Variation in the assigned weight value is another source of uncertainty for these data.

The ACS records information on immigration in their surveys and reports the number of foreign-born respondents. As previously mentioned, the ACS attaches an 'allocated' or 'not allocated' notation to their provided birthplace data. Because I could not find readily available documentation on how survey responses get assigned to either category, this adds another source of uncertainty.

Both the FEMA Flood Hazard area and the NYC Stormwater maps are also not completely accurate portrayals of flooding in NYC. The NYC Stormwater maps are based on topographic data of the city, which isn't granular enough to capture every detail of the city that affects how stormwater flows.

Future work

A potential workaround for the lack of ACS immigration data involves using proxies from the same survey. Both average housing prices and data on the primary language spoken could serve as relevant substitutes for representing immigrant populations around NYC. When more accurate flood maps for the New York City become available, analyses must be made to see who stands most vulnerable to every kind of flooding. Further analyses and data cleaning must be done to make conclusions that have relevance.

Conclusion

As New York City prepares for worsening coastal and pluvial flood conditions, the importance of understanding who is most at risk to flooding continues to be more pressing. The damage and lives taken by Ida can be seen as an example of the kind of flooding that will become more frequent and more extreme as the planet warms and as sea levels rise. Vulnerability to flooding contains many facets, most of which still need to be understood by flood insurance policies and data modeling. The lack of results from this study makes it clear that flood risk and vulnerability may not be understood by examining one variable at a time, and should perhaps be understood using as many as possible. At the very least, more accurate data on both demographics and flood exposure is still needed, even in a city that is as data-rich as NYC.

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