

Richard Barad

ENVS 6111: Flood Plain Management in A Changing Climate

Final Project

Professor John Miller

Due Date: 12/22/2023

Analyzing What and Who is Vulnerable to Flooding in Philadelphia

Contents

Background	1
My Analysis	2
Demographic Analysis	3
Physical Infrastructure Analysis.....	7
Policy Implications.....	8
Case Study Southwest Philadelphia	10
Conclusion.....	12

Background

The city of Philadelphia is located between two rivers, the Schuylkill, and the Delaware River, and many neighborhoods in the city face a high risk of vulnerability to flooding. This vulnerability is going to increase due to climate change. Unfortunately, city policies and local development practices have not always followed best practices when it comes to flood plain management. Hundreds of city residents were left stranded at the Apex Apartment building on Venice Island in Manayunk when the Schuylkill River flooded its banks after the remnants of Hurricane Ida passed through the Philadelphia metro area¹. Residents of Clearview and Eastwick, blue collar neighborhoods in Southwest Philadelphia, are also experiencing a rising

¹ Adam Green and Bernard Brown, In Harm's Way, GridPhilly, September 2023.

risk of vulnerability to flooding due to sea level rise and more frequent extreme weather events².

My Analysis

My project tries to better understand what and who is vulnerable to flooding in Philadelphia, and how who is vulnerable is changing over time. My focus is on coastal and riverine flooding, as defined by the 1% annual chance (100 year) and the 0.02% annual chance (500 year) flood hazard zone mapping produced by the Federal Emergency Management Agency (FEMA). This analysis does not examine infrastructure flooding or flooding risk due to rising sea levels. However, it is important to note that these are also issues which impact flood risk in Philadelphia. Rising sea levels due to climate change has resulted in an increase in flooding in areas along the coastlines within the FEMA flood hazard zones³. Philadelphia is vulnerable to coastal flooding, and this increased risk of coastal flooding will likely impact Philadelphia over the upcoming years. Because of this growing risk, it is important to better understand who is living in and what infrastructure assets are in flood prone areas.

My analysis leverages open data to analyze who and what is vulnerable to flooding in Philadelphia. There are two parts to my analysis: 1) I analyze who is living in census block groups located adjacent to the flood hazard zone defined by FEMA, and 2) I identify geographic areas of Philadelphia with many public amenities and buildings situated within the FEMA flood hazard zones. The results I present here start with a presentation of the city-wide results and trends. I

² John Hurdle, YaleEnvironment 360, Yale School of Environment, As Waters Rise, a Community Must Decide: Do We Stay or Go? <https://e360.yale.edu/features/chronic-flooding-eastwick-philadelphia>

³ Climate Central, Rising Seas, Flooding Coasts, September 27th 2023. <https://www.climatecentral.org/climate-matters/rising-seas-flooding-coasts-2023>

will then present a case study focused on Southwest Philadelphia. I choose to present this area as a case study, because of its high vulnerability to flooding. All my analysis is carried out using publicly available data, and I use open-source Python libraries to carry out both spatial and non-spatial data analysis and visualize results. Parts of this analysis were also used for my final project for MUSA 5500 - Geospatial Analysis in Python. The final deliverable for the python course is an interactive website which can be accessed [here](#). The website is not part of my deliverable for ENVS 6111 but is included for awareness.

Demographic Analysis

The first part of my analysis focuses on identifying the census block groups located near the flood hazard zone as defined by FEMA. I then examine the demographic breakdown of populations living within the census block groups located near the flood hazard zones and analyze how the demographic breakdown has changed over time. The population data comes from the U.S Census Bureau and I leverage a mix of 5-year American Community Survey (ACS) data and decennial data from

Figure 1: Census Block Groups Identified as being near the FEMA flood hazard zone

2021 Block Groups



2010/2015/2018 Block Groups



2000 Block Groups



Sources: Authors analysis based on data from U.S Census Bureau (Tiger/Line Shapefiles) and Federal Emergency Management Agency (FEMA).

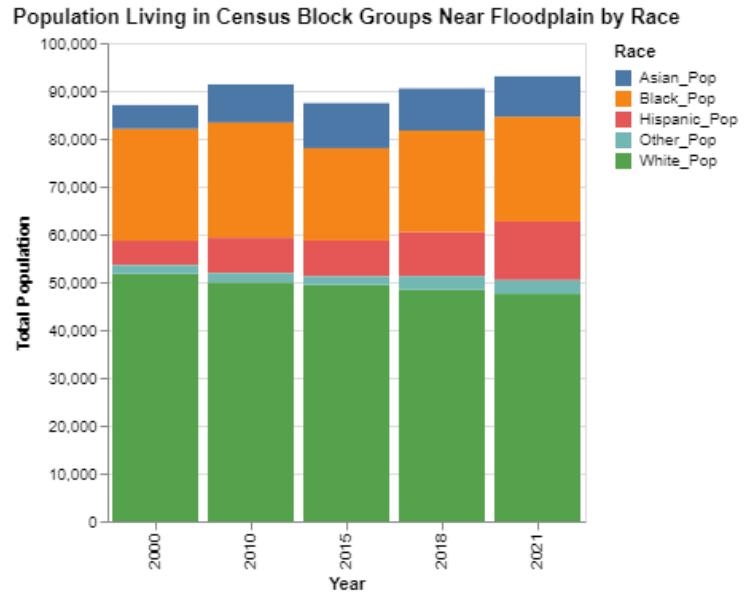
the 2010 and 2000 census. I include population data for five different years: 2021, 2018, 2015, 2010, and 2000.

There are some limitations to keep in mind when looking at census data over time. First, census block group boundaries used for collecting data in 2021 and 2000 are different from those used in 2018, 2015, and 2010 which results in small changes to the geographic extent of the census block groups identified as being located near the flood hazard zone.

In my analysis a census block group is classified as near the flood hazard zone if its centroid is located within the 100 year, or 500-year FEMA mapped flood hazard zone. Figure 1 shows the census block groups that are classified as being

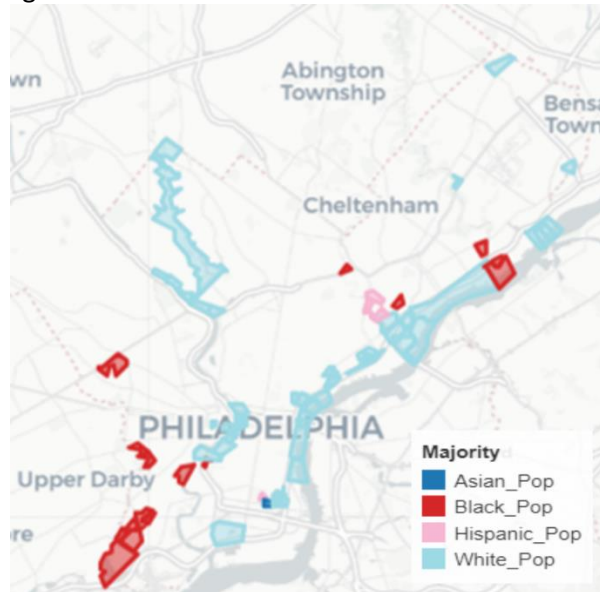
located near the FEMA flood hazard zone. Second, it should also be kept in mind that the data collection methods used for ACS and decennial surveys are different – the decennial data is an

Figure 2: Estimated Population Living in Census Blocks Groups Near the Floodplain by Race



Source: Authors analysis based on data from U.S Census Bureau and Federal Emergency Management Agency (FEMA).

Figure 3: Majority Population in census blocks vulnerable to flooding.



Source: Authors analysis based on data from U.S Census Bureau and Federal Emergency Management Agency (FEMA).

exact count of the population, while the ACS data has a much larger margin of error and is collected over a longer time period.

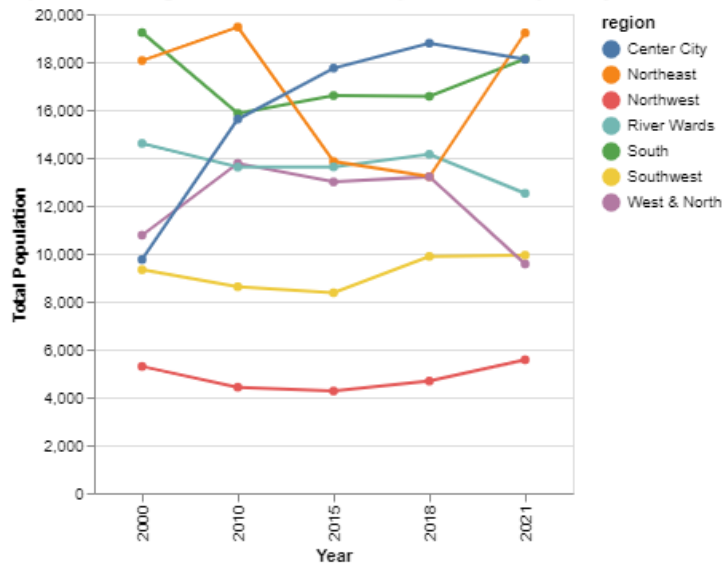
Despite these limitations, the analysis should still allow for the identification of rough trends and patterns over time. Figure two on the right presents the estimated population living in census block groups classified as living near the flood plain. Some notable trends include slow but steady growth in the total population of Philadelphia living in census blocks located near the floodplain except for a slight decline from 2010 to 2015. This may be a result of the shifting from decennial data to ACS as the general trend is upwards in all other years. There is a notable increase in the Hispanic population living in the flood vulnerable areas across the period of analysis.

Figure 3 presents a map of the majority population in census block groups that are vulnerable to flooding. Many of the census blocks vulnerable to flooding such as block groups around the Navy Yard, Fairmont

Park, and the airport do not contain residential housing. Figure 3 only includes block groups that contain residential populations.

The majority race in most of the census blocks west of the Schuylkill is black. There is one census block in South Philadelphia where the majority population is Asian and another where the

Figure 4 Estimated Population Living in Census Blocks Groups Near the Floodplain by Geographic Area of Philadelphia
Population Living in Census Block Groups Near Floodplain by Area



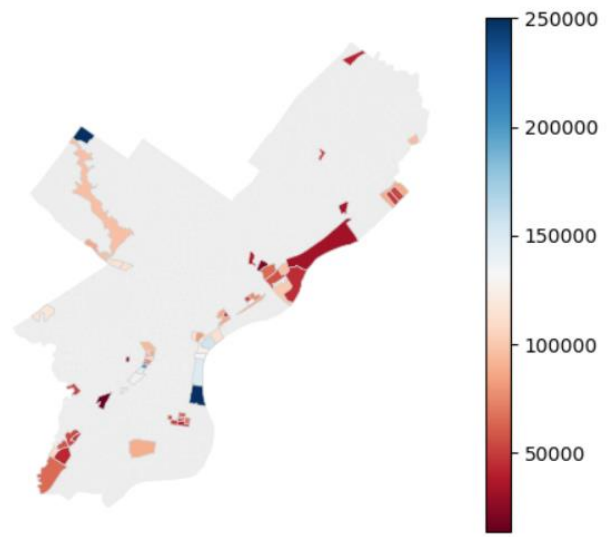
Source: Authors analysis based on data from U.S Census Bureau, Federal Emergency Management Agency (FEMA), and Open Data Philadelphia.

majority population is Hispanic. There is also a cluster of flood prone census blocks in northeast Philadelphia with a majority Hispanic population. My analysis also classifies the city into sections, and I examine which sections of the city have the largest population living in census block groups vulnerable to flooding. The results are shown in figure 4 and indicate that South Philadelphia, Northeast Philadelphia,

and Center City have the largest population living in or adjacent to the flood hazard zone.

Center City has experienced a notable increase in the population living in census block groups adjacent to the flood hazard zone over the past twenty years. Increases are also notable in Northeast, Northwest, and Southwest Philadelphia. Additionally, I examine the median household income for census block groups that are in the flood hazard zone. Examining median household income can help decision makers identify areas where residents are less likely to have the financial resources to respond to a flood event. Figure 5 indicates that census block groups with a flood hazard risk and a low median household income are present in Northeast and Southwest areas of the cities.

Figure 5: Median Household Income in USD for Block Groups located near the flood hazard zone.



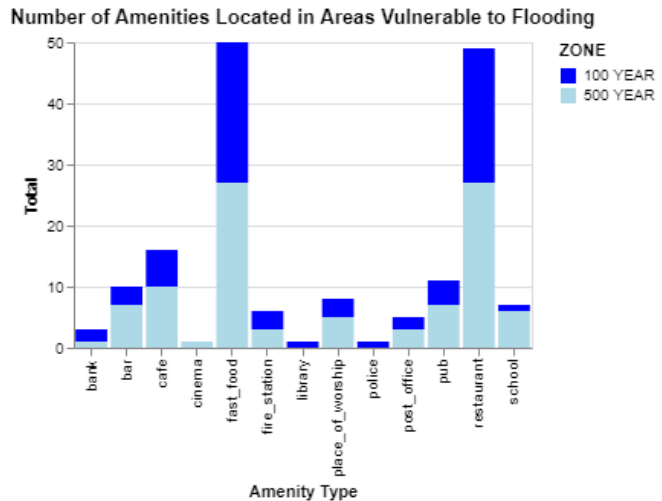
Source: Authors analysis based on data from U.S Census Bureau and the Federal Emergency Management Agency (FEMA).

Physical Infrastructure Analysis

The second component of this work examines the number of infrastructure assets that are in the flood hazard zone. I examine two types of infrastructure 1) Public Amenities and 2) Buildings. The public amenity and building data are downloaded from Open Street

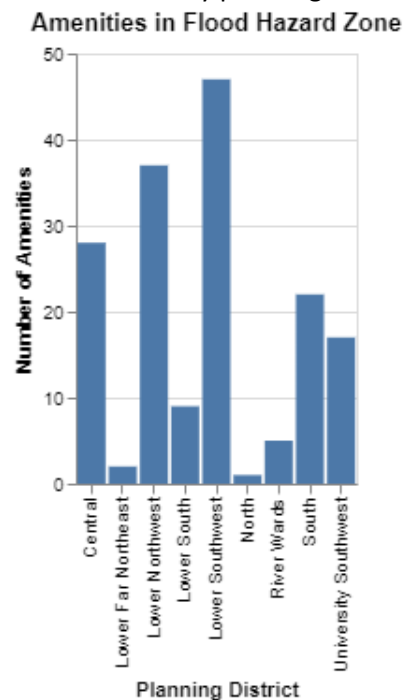
Maps (OSM). The public amenities I examine include places of worship, restaurants, school, cafes, banks, libraries, post offices, fire stations, community centers, police stations, and cinemas. Figure 6 shows the number of each type of public amenity which is located within the flood hazard zone. There are many restaurants located within the flood hazard zone. Additionally, over 10% of fire stations in Philadelphia are located inside the floodplain – this could be cause for concern due to the important role this amenity plays in emergency response. Figure 7 shows the number of public amenities located within the flood

Figure 6: Number of public amenities in flood vulnerable hazard zone



Source: Authors analysis based on data from Open Street Maps (OSM) and the Federal Emergency Management Agency (FEMA).

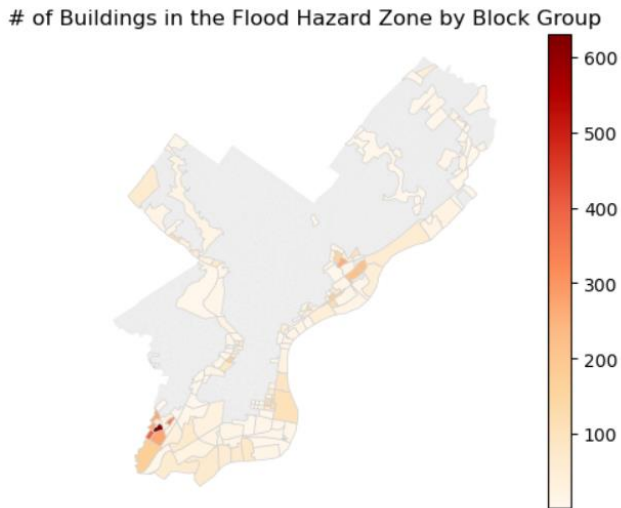
Figure 7: Number of public amenities in flood hazard zone by planning district



Source: Authors analysis based on data from Open Street Maps (OSM) and the Federal Emergency Management Agency (FEMA).

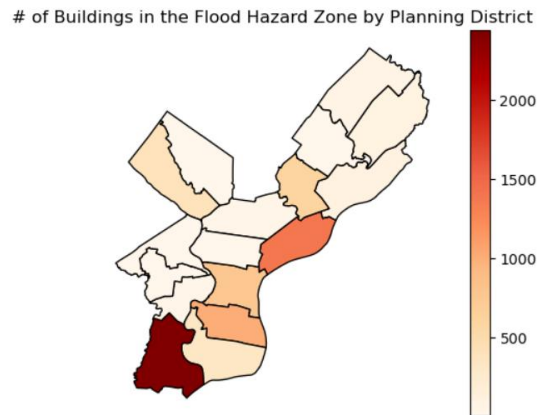
hazard zone by planning district. The planning district with the largest number of public amenities in the flood hazard zone is the Lower Southwest Planning district. The Lower Southwest planning district also contains the largest number of buildings located within the flood hazard zone as shown in Figure 8 and Figure 9. Other areas with many buildings in the flood plain include areas of Center City along the Schuylkill banks and parts of South Philadelphia.

Figure 8: Number of buildings the flood hazard Zone by Census Block group.



Source: Authors analysis based on data from Open Street Maps (OSM), the Federal Emergency Management Agency (FEMA), and U.S Census Bureau.

Figure 7: Number of buildings the flood hazard Zone by Planning District



Source: Authors analysis based on data from Open Street Maps (OSM), the Federal Emergency Management Agency (FEMA), and Open Data Philadelphia.

Policy Implications

As shown, there has been an increase in the population living in center city, northwest Philadelphia, and Northeast Philadelphia. The Apex apartment building discussed in my introduction was built on Venice Island in 2007, and flooded in 2014, 2020 and in September

2021 when the remnants of Hurricane Ida passed over Philadelphia⁴. Many residents of Apex had to be evacuated by boat, and residents received extremely minimal warning from property management about the high risk of the building flooding. The original construction of the Apex was allowed because developers had submitted data to convince FEMA to reclassify the island as part of 100-year flood zone instead of the floodway as building in the floodway is not permitted⁵.

There has also been an increase in the population in Center City living in the flood plain – this is in part a result of new apartment complexes built along both the Delaware and Schuylkill rivers within the flood plain. One such building is the Park Town Place Apartment Building located at 2200 Benjamin Franklin Parkway which also had to be evacuated during the flood events of September 2021⁶. The presence of these apartments in the flood plain is particularly concerning because residents of these properties tend to be renters who are not required to purchase flood insurance and may not be aware that they are living in flood prone area. To prevent future events like the chaos at the Apex it is recommended the city implement laws requiring that landlords disclose flood risk to renters and recommend that renters in flood prone areas consider purchasing flood insurance, especially residents living at or near the ground level. Additionally, it is recommended that stricter rules be put in place on development of residential units within the 100-year flood hazard zone. Unfortunately, there does not appear to be interest in preventing future residential developments in flood prone areas. At the time of

⁴ Adam Green and Bernard Brown

⁵ Adam Green and Bernard Brown

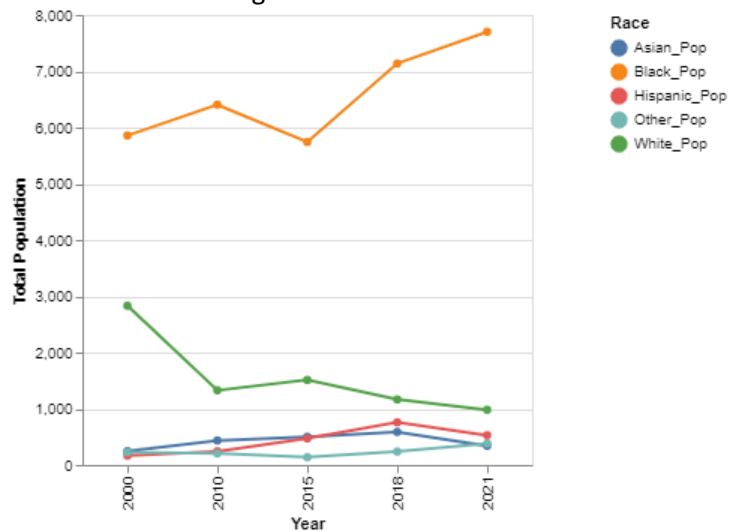
⁶ NBC Philadelphia, Published September 2, 2021, Flooding Forces Evacuation of Center City Apartment Complex. <https://www.nbcphiladelphia.com/news/local/flooding-forces-evacuation-of-center-city-apartment-complex/2946679/>

my analysis, the Navy Yard census blocks did not contain any residential populations. However, the neighborhood is currently being redeveloped and the city recently allowed the construction of residential units despite the Navy Yard being one of the most flood prone neighborhoods in the city. Navy Yard plans to include steps to try to mitigate flooding, but many including Josh Lippert the city's former flood plain manager think the measures being taken are inadequate⁷. Additional new developments are also planned on Venice Island in Manayunk⁸.

Case Study Southwest Philadelphia

This section provides a case study of the Southwest Philadelphia Planning district which includes the neighborhood of Eastwick. As noted previously, this section of the city contains the largest number of buildings within the flood plain. Additionally, many of the homes in the neighborhood

Figure 8: Race Breakdown of the population living in census block groups in Southwest Philadelphia located in area vulnerable to flooding



Source: Authors analysis based on data from the U.S Census Bureau and the Federal Emergency Management Agency (FEMA).

are smaller single-family homes, which results in fewer residents living in the floodplain but the presence of more buildings. Flooding is a larger danger for residents in single family homes

⁷Sophia Schmidt, WHYY, Philadelphia, Thousands of people could live at the flood-prone Navy Yard. Will they be safe? July 19th, 2022, <https://whyy.org/articles/navy-yard-flood-prone-development/>

⁸Vitali Ogorodnikov, Philadelphia YMBY, Renderings Revealed For Venice Island At 4436-44 Main Street In Manayunk, Northwest Philadelphia, <https://phillyyimby.com/2022/10/renderings-revealed-for-venice-island-at-4436-44-main-street-in-manayunk-northwest-philadelphia.html>

because residents live at ground level. This contrasts with areas of center city where most of the buildings in the floodplain tend to be taller apartment buildings. Figure 8 shows the demographic trend of the population living in census block groups located near the flood hazard zone in Southwest Philadelphia. As shown, the white population in these areas declined from 2000 to 2021 while the black population has increased. Additional research is needed to verify this, but it may be the case that white residents of the neighborhood have a greater ability to relocate to other areas of the city,

while Black residents are less able or willing to do so either due to financial circumstances or deep historical family ties to the neighborhood. Figure 9 shows the location of buildings located within the floodplain in the Southwest Planning District. The highest density of buildings is in the far Southwest

Figure 9: Location of Buildings in the Flood Hazard Zone in the Southwest Planning District – buildings shown as blue dots, blue fill is the flood hazard zone.



Source: Open Street Map (OSM), Federal Emergency Management Agency (FEMA), Open Data Philadelphia, and U.S Census Bureau.

section of the planning district, the area where the Eastwick neighborhood is located. There are currently proposals on the table to implement a land swap that would relocate residents in the most vulnerable parts of Eastwick to higher ground. However, many residents are against the idea of relocating to higher ground as it means leaving the community, they have been part of for generations⁹.

⁹ John Hurdle, YaleEnvironment 360, Yale School of Environment, As Waters Rise, a Community Must Decide: Do We Stay or Go? <https://e360.yale.edu/features/chronic-flooding-eastwick-philadelphia>

Conclusion

Overall, the analysis highlights the city of Philadelphia's vulnerability to flooding – both the population and the amount of infrastructure in the flood hazard zone has expanded over the past twenty years. This is concerning given the likelihood of an increase in flooding events due to climate change. The city is facing compounding challenges. First, there is the large amount of new residential development which has taken place in flood hazard zone in center city and areas of Northeast and Northwest Philadelphia. Second, there is the challenge of figuring out how to help long-term low-income residents who live in areas with an increasing vulnerability to flooding and may not have the resources to relocate. Both are challenging issues that the city of brotherly love will need to cope with over the upcoming years.