Financing Floods in Chicago

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Abstract

The objective of this term paper is to study the hydrology and social vulnerability of Chicago, Illinois, and to find if a correlation exists between the two. This project will feed into a larger project to write a green bond package to retrofit low-income, flood prone homes in Chicago. Chicago stands as the 3rd most populous city but has a median income of only $50,434 across the city. This project specifically will investigate the flood history, projected flood risk, and social risk to find correlations. The data gathered will come from municipality records and reports used in city and housing planning, as well as data collected from the US Census Bureau. From the maps made, it is found that the same areas that experience the highest level of poverty and "hardship" are those that face the highest risk of flooding. More importantly, it is recorded that these areas receive the least amount of insurance and are expected to bear a higher proportion of cost from flood damages.

Objective

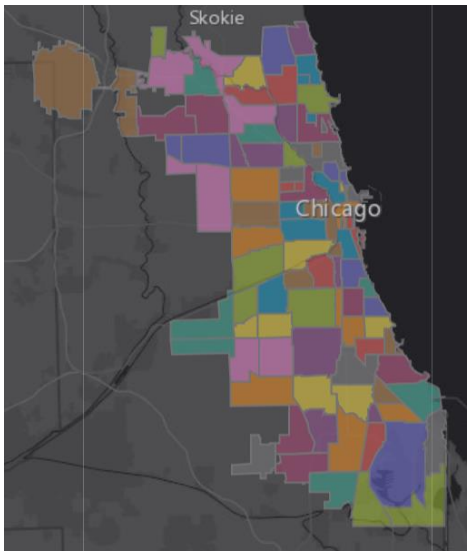
The objective of this paper is to analyze whether or not the rain patterns in the last ten years match the effects predicted from climate change scenarios. Is Chicago facing more intense or more frequent storms? Is there a significant risk to Chicago in terms of flooding? After analyzing flood risk in the city, the "hardship" or social vulnerability of the city will also be analyzed. Do the regions of high flood risk correlate to regions of high "hardship"? Then, this paper will compile data concerning social vulnerability and hardship and compare regions of distribution. The regions of high flood risk will be compared with the regions of high social risk. The purpose of this study is to justify a green bond package to finance the implementation of flooding mitigation and nature-based solutions for flood protection in low-income neighborhoods of Chicago. Connecting high flood risk and high hardship will provide justification to focus resources and energy into these low-income areas that require more financial aid in recovering from flood damage.

Data obtained can be sourced to the US Census Bureau, US Surface Climate Observing Reference Networks, FEMA, and the City of Chicago. No calculations were required for mapped data. For the Intensity-Duration-Frequency (IDF) graph, rainfall data from the Shabbona Station was recorded for every five minutes in the time period of 2008-2018. An IDF curve was created by first finding the 5-, 10-, 15-, 30-, 60-, 120-, 360-,720-, and 1440-minute averages for every year and then calculating the max value for each duration. The maximum from each year were then used to predict the rainfall per hour for a 2, 5, 10, 20, 50, 100, and 1000-year flood.

Social Risk vs. Flood Risk

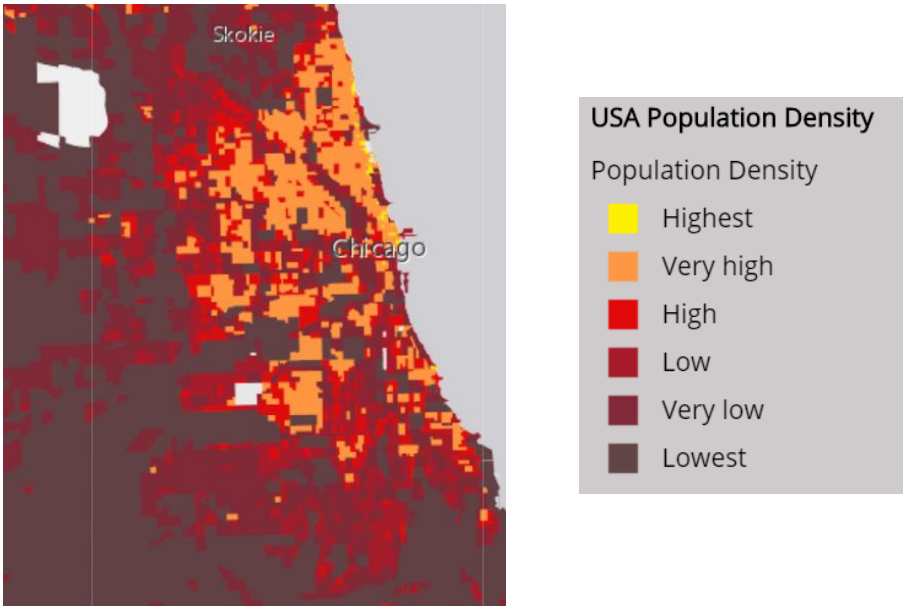
The City of Chicago is situated in the northeast corner of Illinois, along the shores of Lake Michigan. With a population numbering around 3 million people[1] across over 100 neighborhoods[2], Chicago is ranked the 3rd most populous city in the United States[3]. It is home to over 77 community centers and 50 wards[4]. The city has a population density of 11,868 people per square mile, ranking it as the 75th most population dense area in the US[5]. The areas within the city that are denser are found closer to the shores, as seen in Figure 2. The most population dense neighborhoods are found north of the city center and along the shoreline, while the south end of the city houses more "high" population dense neighborhoods interlaced with "low" dense areas.

Figure 1: Neighborhoods of Chicago



[1] "Chicago city, Illinois". *United States Census Bureau.* 2017. https://www.census.gov/quickfacts/fact/table/chicagocityillinois/PST045217
[2] "Facts and Statistics". *City of Chicago*, Office of Mayor. 2018. https://www.cityofchicago.org/city/en/about/facts.html
[3] Ibid.
[4] Ibid.
[5] "Land Area, Population, and Density for Places and (in selected states) County Subdivisions: 2010". *United States Census Bureau,* Population Division. 2013.

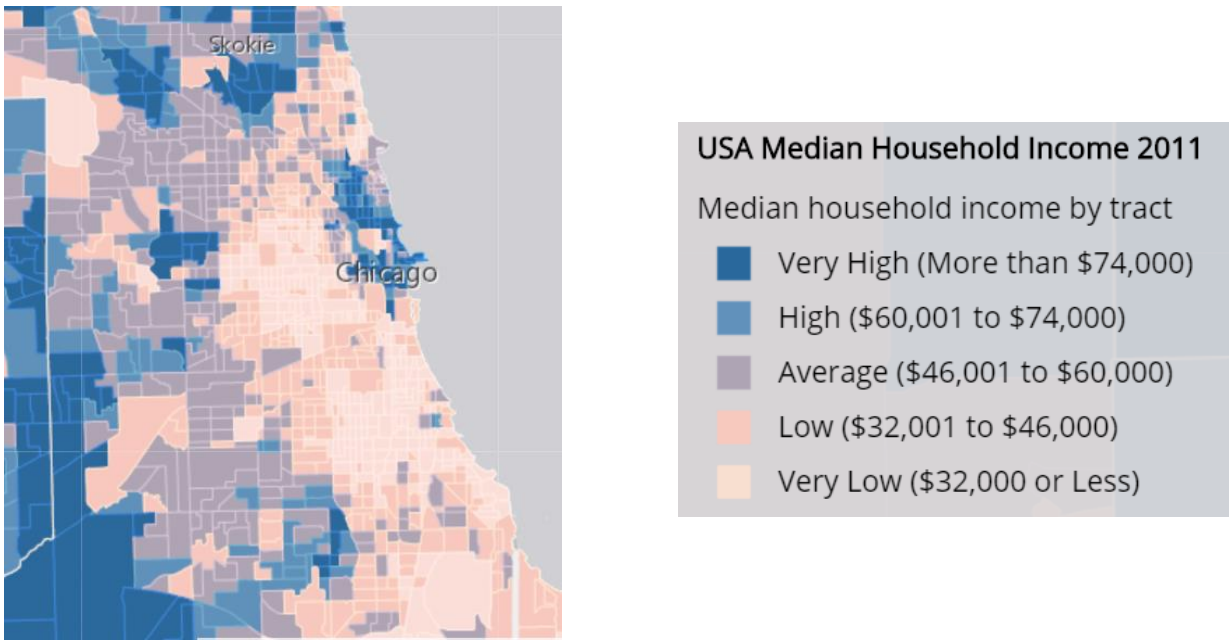
Figure 2: Population Density in Chicago



There is around 11% of the population 65 years and older and around 22% of the population 18 years and younger, according to the 2016 Census[6]. The younger populations live closer to the city center and south of the city, while many of the older neighborhoods live on the outskirts of the city in suburbs. However, Chicago is not immune against the grappling hands of poverty. Over 20% of Chicago fell under the national average poverty line in 2016, averaging a $32,000 income per year per capita[7]. The median income across the city is $50,434[8]. As seen in Figure 4, the poorer neighborhoods lie in the center of the city and to the south, where we saw in Figure 2, there are less dense neighborhoods.

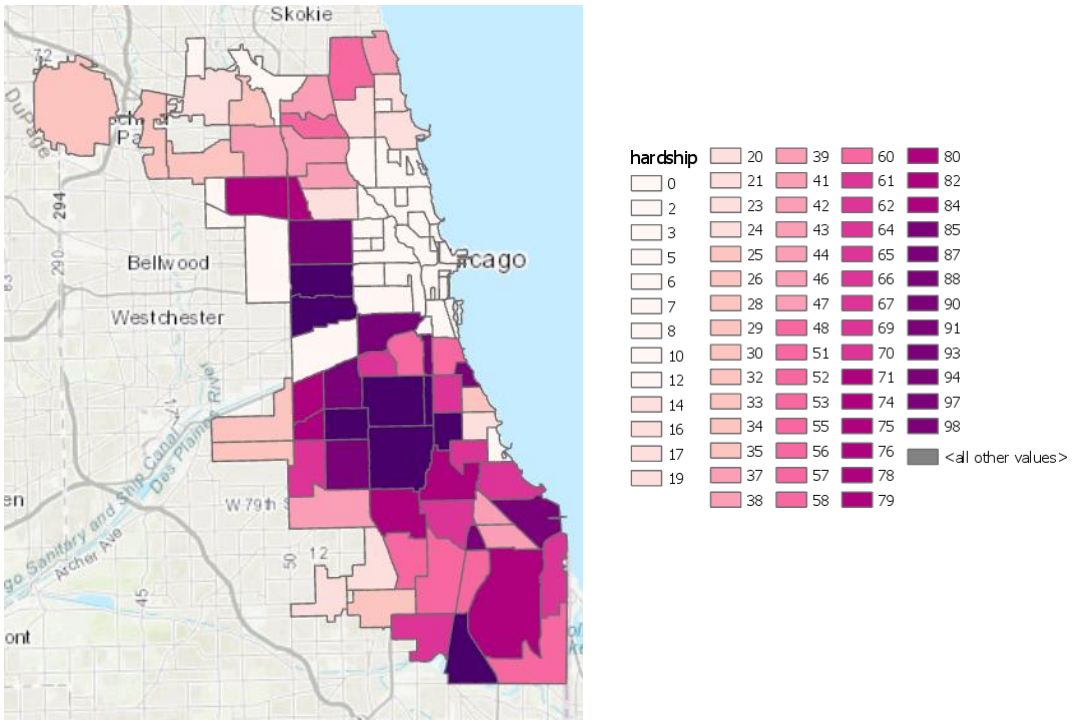
[6] "Chicago city, Illinois". *United States Census Bureau.* 2017. https://www.census.gov/quickfacts/fact/table/chicagocityillinois/PST045217
[7] Ibid.
[8] Ibid.

Figure 4: Median Income



Using US Census data, the Chicago community area created a hardship index. The hardship index takes into account percent of occupied housing units with more than one person per room, percent of households living below the federal poverty level, percent of persons aged 16 years or older in labor force that are unemployed, percent of persons aged 25 years and older without a high school diploma, percent of population under 18 or over 64 years, and per capita income. The data was collected and calculated at tract-level estimates. The hardship index compiles these factors and can be used as a proxy for social vulnerability in the city. The index ranges from 0-100 with 100 being the maximum hardship. According to this map, the highest hardships are south of the city. This is compounded with what was seen in the maps for income and age; those most vulnerable to both social and political events, as well as physical and natural events are younger and poorer than other groups in the city.

Figure 8: Hardship Index



Chicago is surrounded on the east side by Lake Michigan. Chicago also intersects with three other major waterways. There is the Calumet-Sag Channel which flows into Lake Calumet on the southern edge of the city. Running through the north is the Chicago River. The city also has the Des Plaines River on the western outskirts[9]. Chicago, unlike any other city around the world, is now concerned with the impacts of climate change. According to FEMA, by 2100, there will be an increase of 45% in at risk of flooding areas[10]. This could lead to more than a 90% increase in property losses[11]. According to data compiled by a group of students in Stanford University, in 2050, Chicago will see an additional 11-50 mm of rainfall[12].

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[9] "Chicago Area Waterway System/Chicago River". *US Environmental Protection Agency*, EPA in Illinois. 2017. https://www.epa.gov/il/chicago-area-waterway-system-chicago-river

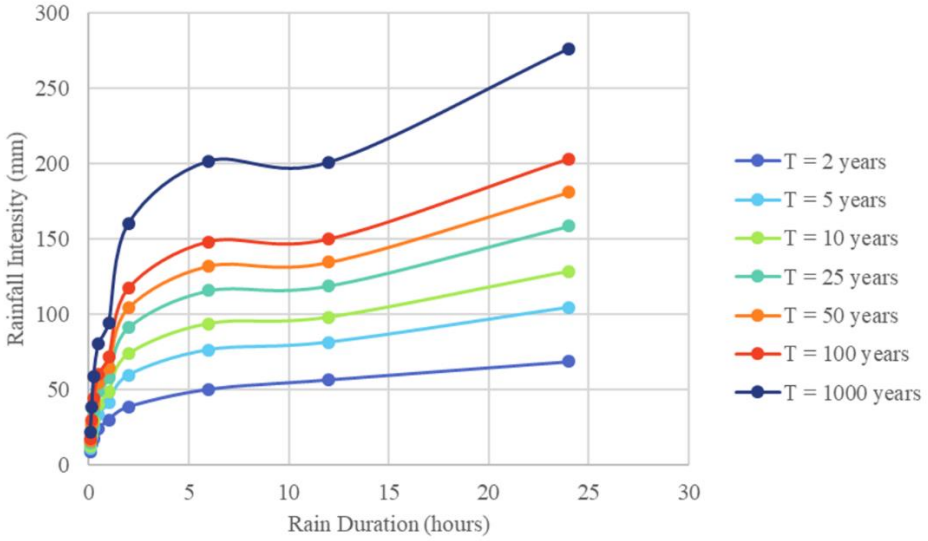
[10]Lehner, Peter. "New FEMA Study: Climate Change will greatly Increase Flood Risk, Debt." *NRDC.* 19 June 2013. https://www.nrdc.org/experts/peter-lehner/new-fema-study-climate-change-will-greatly-increase-flood-risk-debt

[11] Ibid.

[12] Alexis Mychajliw, Elizabeth Hadly, Shane Johnson, and Charlie Jiang. "Key Problem of Global Change: Climate Disruption". *ArcGIS*, 2018. https://ut-austin.maps.arcgis.com/home/item.html?id=adcb20ad587448c8be5255988862b086

Below is the IDF curve created from the data from the U.S. Surface Climate Observing Reference Networks. Here we see each rainfall intensity plotted against rainfall duration, for each storm probability. This graph can now be used to evaluate the storms Chicago has been facing for the past ten years. Going back to the U.S. Surface Climate Observing Reference Networks rainfall data, 2008 and 2011 are seen to have two-hour storms with a rainfall of 174 mm and 120 mm, respectively. Using the IDF curve, the 2008 event falls on the 1000-year storm track and the 2011 event falls on the 100-year storm track. The increase in rainfall is about 50 mm, over only 3 years. This is a similar increase calculated by Mychajliw et.al., who projected an increase of rainfall by 11-50 mm by 2050[13]. It should be noted, however, that the 2008 and 2011 flood events were isolated incidents; before and after these events, there was little to no precipitation.

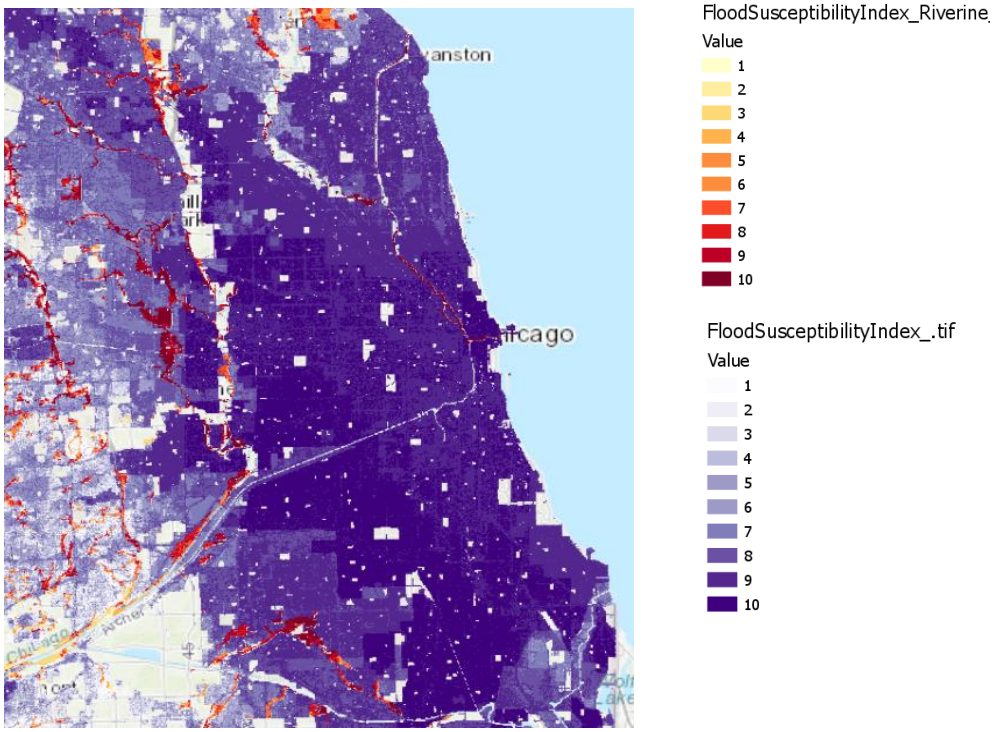
Figure 6: IDF Curve-Shabbona Station



[13] Ibid.

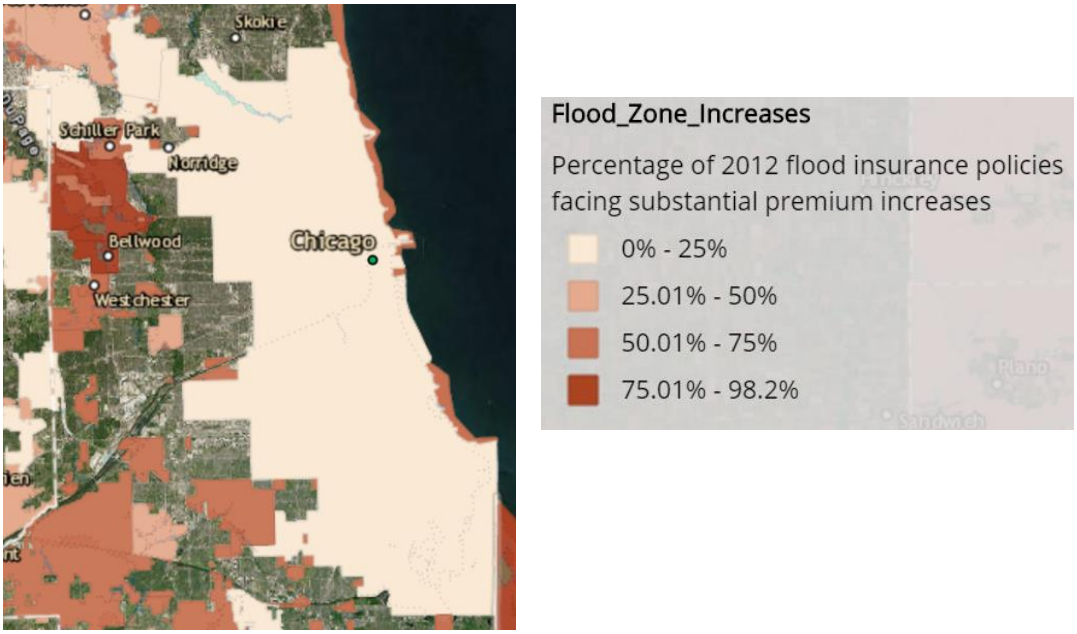
Using data from FEMA, Chicago counties, and the city itself, Chicago Metropolitan Agency for Planning (CMAP) created Flood Susceptibility Indices (FSI) that relate the geographical areas of flood with flood risk. FSI considers overbank flooding, surface ponding, overland flow, water seepage, and basement backups. The places surveyed have reported and experienced flooding from 2007-20217. These "address level" rasters are plotted and used to create larger scale mitigation strategies across the city. The FSI ranges from 0-10, with 10 being the maximum susceptibility for flooding. The darkest blue represents higher susceptibility to urban flooding while the darkest red represents higher susceptibility to riverine flooding. According to this map, the regions more susceptible to urban flooding are in the city center and to the south, with values of 10. The highest susceptibility to riverine flooding lies in the outskirts of the high urban flooding regions, with maximum values also at 10. The riverine flooding is seen along the Calumet-Sag Channel and just north of the Des Plaines river.

Figure 7: Urban and Riverine Flood Susceptibility Index (FSI)



It was seen in 2012, according to the figure below, that Chicago faced a 0-25% increase in premiums for flood insurance policies. These policies however are not tailored to income and paying power of the resident. It is in great need that the city creates an insurance profile unique to the damages and existing social vulnerability index of the residence.

Figure 5: Increases in Insurance Premiums



Conclusion

From the graphs and maps produced, we can see a correlation between flood risk and social vulnerability. Those that are hit hardest by intense rainfall and flooding are the ones who are the least capable in paying for damages. According to a paper released by Community Network Technologies, 67% of the claims made by residents with the highest damages fell under the mean average income. In addition, only 8% of the claims across all neighborhoods were paid by the National Flood Insurance Plan (NFIP)[14]. These residents lie in flood zones that will only

[14] "The Prevalence and Cost of Urban Flooding". *Community Network Technologies*. 2014. https://www.cnt.org/sites/default/files/publications/CNT_PrevalenceAndCostOfUrbanFlooding2014.pdf

increase in intensity and duration due to climate change, but there is nothing in the works to mitigate the risk of both flooding and residential damage. Additionally, the city has not taken a focused action for those in the southern neighborhoods of the city, and instead are putting out city wide mandates for insurance policies and registration.

The next steps of this project are to create an insurance profile for the city of Chicago. With each neighborhood, a list of claims and premiums should be drafted and then compared to other neighborhoods of equal damage and/or equal hardship index. After understanding how the city is currently financed, engineers and city planners need to bring together to analyze how current drainage and flood protection instruments can be modified and enhanced to allow for more protection. Nature-based solutions and the use of existing pipes can help alleviate risk while remaining cost efficient. Finally, after combining the results of new technological and spatial solutions with a retrofitted insurance profile for the city, a green bond package needs to be drafted and presented to investors, in hopes of financing the project in low-income, high-risk neighborhoods of Chicago.