Mapping the Vulnerability to Flooding of Community-Development Corporations (CDCs) Affordable Housing Properties in Central and East Harlem, New York City

Veronica Olivotto[1] and Eddy Almonte[2]

[1]Milano School of Policy, Management and the Environment, The New School
[2]Graduate School of Architecture, Planning and Preservation, Columbia University

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Abstract

New York City's affordable housing stock is vulnerable to coastal flooding under current and projected climate scenarios. Flood vulnerability in this study, was intended as a factor of the exposure of affordable housing units to current and future floodplains as well as topographical elevation. Variables of socio-economic vulnerability included median household income by census tract, expiring affordability of rent-subsidized housing, and East Harlem's most recent rezoning . The affordable housing in question is owned by two community-development corporations (CDCs) of the Northern Manhattan Collaborative (NMC), Hope and Ascendant based in East Harlem. Using GIS software and publicly available data from NYC Open Data and Mapluto, large scale mapping was conducted at the Borough-Block-Lot (BBL) scale to understand the exposure to coastal flooding of 101 properties owned by Hope and Ascendant, as well as a Hotspot Analysis of all the remaining units included in the NMC (48 more properties). Results show that Hope properties may flood more than Ascendants', under both current and future floodplain projections. A contributing factor is topographical elevation, where Hope Properties are at lower median elevation (13.2 feet) than Ascendants' (29 feet) and also lower than the median elevation of both Central (22 feet) and East Harlem (15 feet). Results from the hotspot analysis shows that 20 of Hope Properties fall within Hot clusters of socioeconomic vulnerability, as well as 5 of Ascendant Properties. Overall the NMC Properties show a higher socioeconomic vulnerability than all the properties in East Harlem. This result is important considering that New York City's stock of affordable housing hosts some of the most vulnerable populations in the city, with less ability to move elsewhere before or after a flooding event.

This project was initiated as the final product for the course 'Introduction to GIS' (Fall 2018) at the New School and continued through the collaboration with Eddy Almonte, Morgan Stanley Community Development Fellow at Ascendant Neighborhood Development. A poster version of the project was presented at the 10 Years of the New York Panel of Climate Change, at the Academy of the Sciences of New York City on March 15, 2019

Introduction

New York City (NYC) is affected by three types of floods: coastal, riverine, and inland. Riverine floods are the least common and least severe type in NYC. Inland floods (flash floods) are caused by stormwater. These floods are difficult to predict and manage as their occurrence is driven by small intense thunderstorms, local land characteristics, and the complex sewer network. Coastal and riverine flood risk can be defined using FEMA flood maps for the 100-year storm, but inland flood risk and vulnerability are difficult to quantify. NYC manages this risk through several mechanisms including: regulatory codes and laws, stormwater management improvements, flood-proofing and elevating buildings, and protecting critical infrastructure (New York City Emergency Management, 2014).

NYC has experienced 7.5-foot floods several times in the past decade. Superstorm Sandy discharged 10- or 11-foot of coastal floods on much of Manhattan, Brooklyn, and Staten Island, killing 43 people and inundating more than 88,000 buildings (Atlantic, 2017). New York City has 178,000 units of affordable rental housing that are privately owned by corporations and receive government assistance through the U.S. Department of Housing and Urban Development, the Mitchell-Lama program, or the Low Income Housing Tax Credit program. According to a research conducted in the aftermath of Sandy by (The Furman Center, 2013), this stock was affected by Sandy: 248 subsidized buildings, with about 24,500 units, are located in areas reached by Sandy's surge. Fig.1 below shows that subsidized developments are concentrated in some surge affected areas, such as Coney Island, the Rockaways, Harlem, and the Lower East Side.

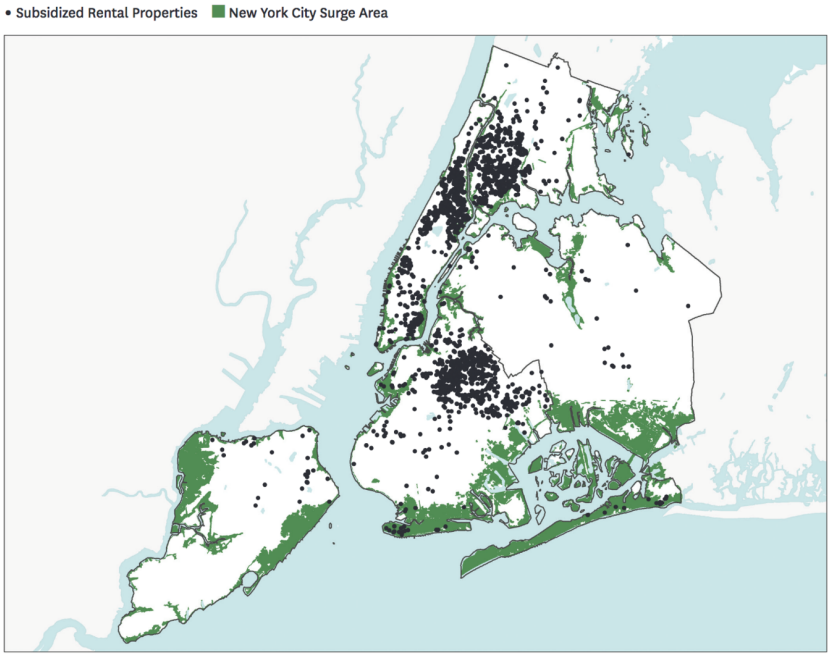

Figure 1: Sandy Surge Area and Subsidized Rental Properties in New York City (Source: FEMA Modeling Task Force, Furman Center Subsidized Housing Information Project, New York City Department of City Planning, New York State Office of Cyber Security)

Among NYC's corporations owning stock of affordable rental housing are Hope and Ascendant. Hope's Property Management Department services and Ascendant Neighborhood Development (the former referred to as HOPE and the latter referred to as AND from now onward) are two community-based not-for-profit affordable housing organization based in East Harlem. The two organizations are part of a larger coalition of CDCs, called the Northern Manhattan Coalition (NMC), which in total represents 157 affordable rental properties. Both organizations advocate for the preservation of affordable housing in New York City, "as rapid increases in market-rate residential and commercial development propel speculation, drive up rents, and encourage tenant harassment and displacement" (AND website). Just 22 percent of rental units in New York City are affordable to households whose annual income is below $30,000. Both organizations also work to strengthening the neighborhood's social fabric by assisting in the growth and success of local businesses, by assisting residents to enhance their lives and incomes, and by sponsoring community programs.

HOPE owns over 1,300 affordable apartments in more than 78 buildings throughout Central and East Harlem (Community District 10 and 11). AND owns over 628 apartments in 28 buildings. During a meeting at the New School both Hope and Ascendant, expressed the need for evidence-based mapping to understand the exposure to flooding to their properties. Following a meeting with Hope, one of the main problems seems to be 'blue sky flooding', the type of flooding occurring without stormy weather and influenced by high tides at seas, high ground water table and surface elevation. There is anecdotal evidence that this type of flooding affects basements, which are recurrently flooded, but for which Hope has very little funding for left over after what goes towards regular building maintenance. Moreover, Hope has

been receiving a number of violations from ConEd, NYC's energy company, because as flooding affects basements, officers cannot access gas and water readings stored there. Because of these violations, HOPE has been unable to close housing retrofitting deals with for-profit-banks they partner with. At the same time HOPE has been an early adopter of green infrastructure, like green rooftops and gardens, thanks to funding made available by the city. However, green rooftops address a different problem: they slow down excess rainfall but they do not slow down water coming from below, or from coastal storm surges.

Initially this study was going to access data on occurrence of inland flooding in basements from the building manager service SiteCompli. This website contains information about the violations that both organization incur year round since 2012. A close inspection of the data revealed that violations are filed for issues such as "sewer backup" but no further explanation is given about whether the violation was filed because inspectors could not access the basement due to flooding. The number of complaints related to sewer backup was also too small to warrant visualization through GIS mapping (36 complaint between 2010 and 2018). The fact remains that, so far, violations descriptions are not capturing important information about whether the violation is issued as a result of the inability of inspectors to access the basement due to flooding. Therefore we based our analysis on coastal flooding alone but we recommend Hope and Ascendant Property managers to produce a protocol for collecting more accurate descriptions of violations occurring as consequence of flooding. In the long term, we see a need for quantifying the hidden recurrent costs due to basement flooding, adding to the burden of regular housing maintenance costs.

A Framing for Flood Vulnerability in New York City

This project aims at a large scale mapping of the vulnerability to coastal flooding of both Hope and Ascendant properties. GIS is used for this purpose. GIS and remote sensing are critical tools for analyzing, preparing for, mitigating, and responding to natural and human-induced disasters, including from flooding events (Huang, 2009)(Strobl et al., 2012). Geo-spatial technologies are used to estimate the risk of occurrence of a disaster based on physical and/or social dimensions. These two dimensions are brought together in the concept of risk, which is a function of a hazard, the exposure to it and social vulnerability, defined below after (Rosenzweig et al., 2011; Kaźmierczak and Cavan, 2011). Although there may be many variables influencing exposure to floods, here I refer to exposure as the susceptibility of people, properties and systems to being affected by an environmental related hazard (Cutter, 2005; Cutter, 2012), which in this case is understood to be the current and projected floodplain in Central and East Harlem, New York City. We furthermore consider as elements of exposure the number of affordable housing buildings and their topographical elevation. In terms of socio-economic vulnerability, we considered three variables that can compound the threat of CDCs housing units to present and coastal flooding in East Harlem. In East Harlem the percentage of people living below the federal poverty level is slightly higher (22%) than the mean for the whole city of New York (20.5%, U.S. Census, 2010), and research shows that people living in poverty and who are socially marginalized have reduced capacity for self-protection in terms of mitigating flood hazards at home pre-event, evacuating in response to flooding, or returning home or to employment in the aftermath of a flooding event, accessing social protection such as flood insurance, hazard mitigation infrastructure, emergency response information and assistance (Collins, 2009; Collins et al., 2012; Elliott and Pais, 2006; Maldonado et al., 2015).

The second variable of socio-economic vulnerability is related to the benefits and drawbacks of urban rezoning plans. Changes in land use zoning and floor area ratio (FAR) permits can have important impacts on neighborhoods' populations by increasing property costs and influencing housing careers, skewing access to services and utilities, affecting the distribution of parks and public space. Rezoning can lead to increased density and waste water pumping needs These impacts can lead to the progressive displacement of low-income socioeconomic groups but also of certain land-uses such as industrial land uses and manufacturing (Curran, 2007). The changing of land uses can imply the loss of economic stability for working-class communities (Wolf-Powers, 2005) and their ability to equally access opportunities and privileges in society. In this study we pay attention to the urban blocks interested by the East Harlem Rezoning Plan approved by the New York City Council in 2017, and which is expected to result in a net increase of approximately 3,500 dwelling units, a substantial proportion of which are expected to be affordable. However, this portion may be allotted to for profit developers instead of CDCs, who can guarantee to keep the rent to a level of affordability in line with the needs of the poorest segments of society. There is reason to believe that the East Harlem Rezoning will just hand over more of the affordable housing stock into the hands of property developers, reframing what affordability means by potentially increasing the density of market rate housing or changing the ways in which local people can afford the amenities in their neighborhood. This is troubling for two reasons: the share of severely burdened renters, among the 921,000 renter households in New York City remains steady at 22% (Citizens Budget Commission, 2018). At the same time, over the past decade or so, New York city housing has been shifting in favor of more middle and high priced rentals, in a glaring erosion to the inventory of rent regulated housing (Stringer, 2018).

The third variable of socio-economic vulnerability is represented by the date of expiration of the affordable rent subsidy. In exchange for a government subsidy, privately owned, publicly subsidized rental housing corporations agree to keep units affordable to low- and moderate-income households for a set number of years, typically 30 years. After a regulatory agreement expires, however, owners can begin to rent their units at market rates. This, however would not be possible for corporations like Hope and Ascendant, whose mission is to provide and maintain affordable housing. Hope and Ascendant, apply for subsidies, at the federal level, to the U.S. Department of Housing and Urban Development (HUD) and the city level, to the NYC Housing and Preservation (HPD). We account the subsidy expiration as a possible socio-economic vulnerability because, should the subsidy fail to be renewed the tenants risk rent spikes or evictions. According to a 2016 analysis by the NYU Furman Center, by 2020, the regulatory agreements governing of 157 federally subsidized residential properties in New York City are set to expire. Over the following decade, an additional 593 will follow suit (The Furman Center, 2016).

This large scale mapping project aimed to answers the following questions:

1. How many Hope and Ascendant properties are in the current and future floodplain?
2. How do Hope and Ascendant buildings compare with the rest of the buildings in Central and East Harlem?
3. What is the average elevation of flooded and not flooded BBL under different flood scenarios?
4. Where are high or low socio-economic vulnerability clusters located within East Harlem?

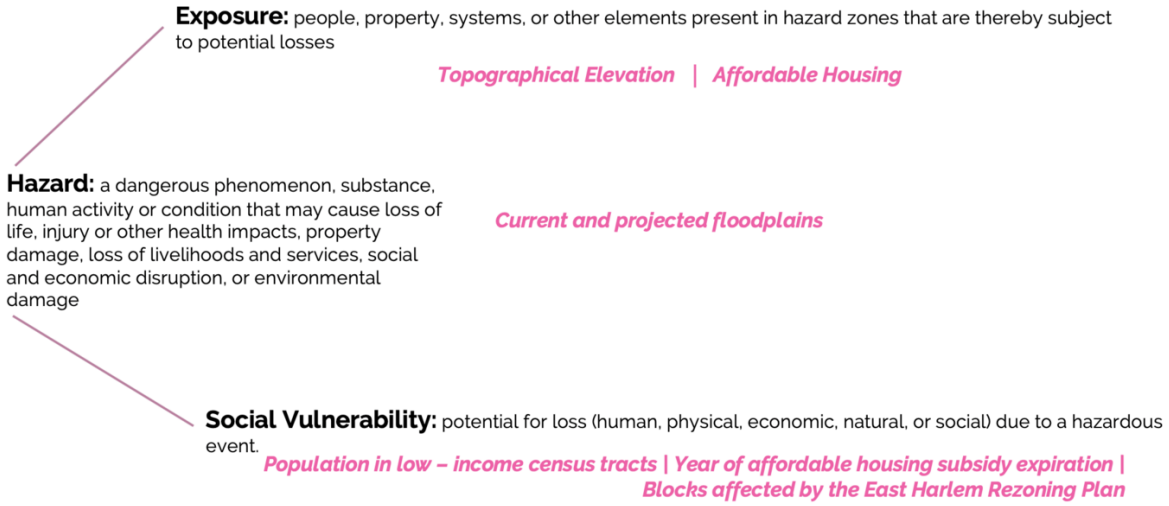

Figure 2: A Framing of Flooding Vulnerability in New York City

Authors' statement of overarching rationale

We believe that universities (private and public) should serve citizens' interests and bridge the disparity in knowledge available to community groups that have less resources to access tools/software/data to build effective arguments against both the systemic forces of history (struggles for affordable housing, better living conditions and the myriads of events and practices of life) and the - no longer - extraordinary climate-induced events like coastal and stormwater flooding.

Methods & Analysis

In order to map the H&A properties in current and future floodplain, we engaged in the following:

1. Retrieved property data from Hope (not geo-located and with not practical BBL numbers) and from Ascendant (already geo-located but with projection issues)
2. Re-coded BBL numbers for both properties from scratch through padding numbers and concatenation
3. Conversion Tool - Convert Exl into Table
4. Table join between properties BBL and Mapluto BBLs for Manhattan but 6/100 properties did not join. I figured out that some addresses that I had initially split into two (e.g. 242-244 East 106 Street) should be kept as one because splitting them generates a new BBL code that of course does not exist. After I joined the address back I solved 5 of 6 missing BBL which were not joining.
5. Selected all null (not joint attributes) and selected inverse to obtain only BBLs in CD 10 and 11, where properties are located. Exported data selection as shapefile.

6. Created 1 field per floodplain (2015, 2020, 2050) set with a short integer and all values at 0 (NOT IN FLOODLAIN). From the FEMA 2015 I selected by attribute only the 100 year floodplain
7. Selected by location - from the BBL with condition of intersecting with floodplain 2015, 2020, 2050, 2080. Each time I selected with field calculator BBLs that intersected with each floodplain and I assigned the intersection at 1 (IN FLOODPLAIN)
8. Created another column where I aggregated all numbers to understand the BBLs that fall in the floodplain at none, one, two or all projections.
9. I decided to represent the different floodplains in three colors and code the properties (1 Ascendant; 0 Hope) and assign different colors to both. Another way I could have done this was to color code the chronology of flooding from green to red depending on 3 (floods in 2020), 2 (floods in 2050), 3 (floods in 2080) but I realized I also needed to distinguish the properties. I tried do choose "Many values" under Symbology and assign both coding for floodplain and coding for type of property (distinguishing them through a specific pattern applied to a solid color). The result was not satisfying because, especially in the overall map the zoom levels are not appropriate to show the details of the patterning.
10. Exported Attribute table to Excel and performed a yearly rate of change analysis on the total number of buildings exposed to different floodplains as well as yearly rate of change for each property type. I used the following formula: =(new_value-original_-value)/(original_value) where original_value represents the value that the percentage of change is based on, and new_value represents the value that has changed. I then divided what I obtained by the number of years (2080-2015) that is 65
11. Created **Map 1** showing all floodplains and the percentage of properties affected by flooding under each scenario
12. Created **4 small multiple maps** showing a zoomed in version of Map 1. The zooms were chosen based on where it most flooded in each projection.

In order to compare the percentages of H&A buildings flooding to those in Central and East Harlem I engaged in the following steps:

1. Repeated steps 6 to 10 to calculate amount of BBLs in both Central and East Harlem that are flooded under each projection
2. Created **Map 6** where I show the percentage and yearly rate of flooding of all buildings in Central and East Manhattan

Finally in order to calculate the average H&A properties elevation in relation to floodplain hazard, I:

1. Used Zonal Statistics as Table, where under "Input raster or feature zone data" I selected the H&A BBLs properties, in Zone field I selected 'BBL' under "Input value raster" the DEM clipped and mask to Central and East Harlem. Under statistics type I choose MEAN and I repeated the operation to obtain the MEDIAN elevation of the properties.
2. Made a Table join on "BBL" between the table produced by zonal statistics and the table with H&A properties.
3. Opened the table and on MEAN I chose ' Summarize SUM Floodplain' to the average MEAN elevation and saved it outside the geo-database as text file so I could work it on Excel.
4. The result is **Map 7** where I color coded different elevations (from 10 to 70 feet) of all

properties and relate this to all floodplains.

In order to demonstrate socioeconomic vulnerability and exposure to urban change, we:

1. Retrieved property data of remaining units from the NMC (46 in total) within East Harlem with expiring rent subsidizations from city, state or federal programs. We table joined the expiring subsidy data to Mapluto using the BBL number.
2. Retrieved shapefiles for census tracts that have a median household income of $30000 or less for a family of four from the ACS 2017 5 year Estimates. We selected $30000 because that is the income limit for the federal poverty level.
3. Retrieved shapefile for the 2017 East Harlem Rezoning from NYC Planning; residential and commercial districts within the rezoning were up-zoned for new higher density development and investments. Expansion of the Second Ave Subway also fall within this rezoning.
4. We made a Vulnerability Ranking to visualize property lots that fall within various floodplains and exposed to certain socioeconomic conditions related to urban change on a temporal scale (EH rezoning and low income census tracts). Each indicator is given a score, described below, and property lots (BBLs) are assigned a score of 0-10, with the most vulnerable BBLs assigned at 10. BBLs that fall within FEMA 2015, NPCC 2020, 2050 and 2080 floodplains are given a score of 1 for each floodplain, with a max cumulative score of 4 if they fall within all four. BBLs with units that have affordable housing subsidies expiring between 2010-2020 are scored at 3, 2020-2030 at 2, and 2030 and 2040 at 1. BBLs that fall within the EH rezoning are scored at 2, given that rapid urban change and investment will likely to occur in 5-10 years. BBLs that fall within a low income census tract are scored at 1.
5. Using the Vulnerability Scores, we then performed a cluster analysis using the Hot Spot Analysis (Getis-Ord Gi*) tool. The BBLs were clustered according to their vulnerability scores, which produced maps with cold and hot spots using polygon contiguity conceptualizations.

Results

In this project we asked four questions: 1) How many Hope and Ascendant properties are in the current and future floodplain? How do Hope and Ascendant buildings compare with the rest of the buildings in Central and East Harlem? 3) What is the average elevation of flooded and not flooded BBL under different floodplains? and 4) Where are high or low socio-economic vulnerability clusters located within East Harlem?

To answer question 1, the results in Figure 3 show that under the 2015 FEMA Floodplain 20% of Hope's buildings flood, while 12% of Ascendant's flood. In the NYPCC 2020 projected floodplain 37% of Hope's and 31% of Ascendant's properties may flood. Under the NYPCC 2050 projected floodplain 57% of Hope's and 35% of Ascendant's may flood. Finally under the NYPCC 2080 projected floodplain 84% of Hope's and 38% of Ascendant's properties may flood. Fig. 4 represents the same data in GIS.

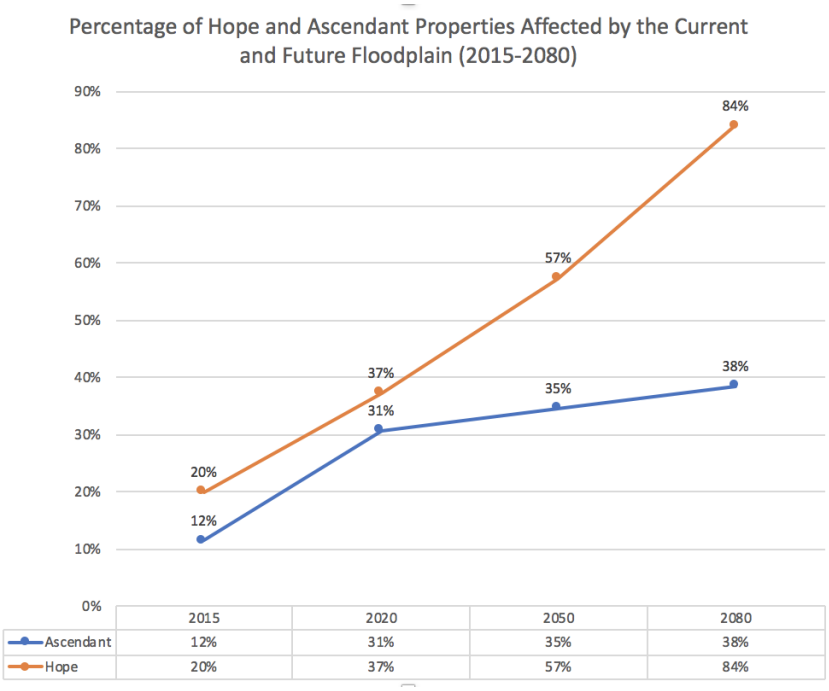

Figure 3: Percentage of Hope and Ascendant Properties Affected by Flooding under current and future floodplain

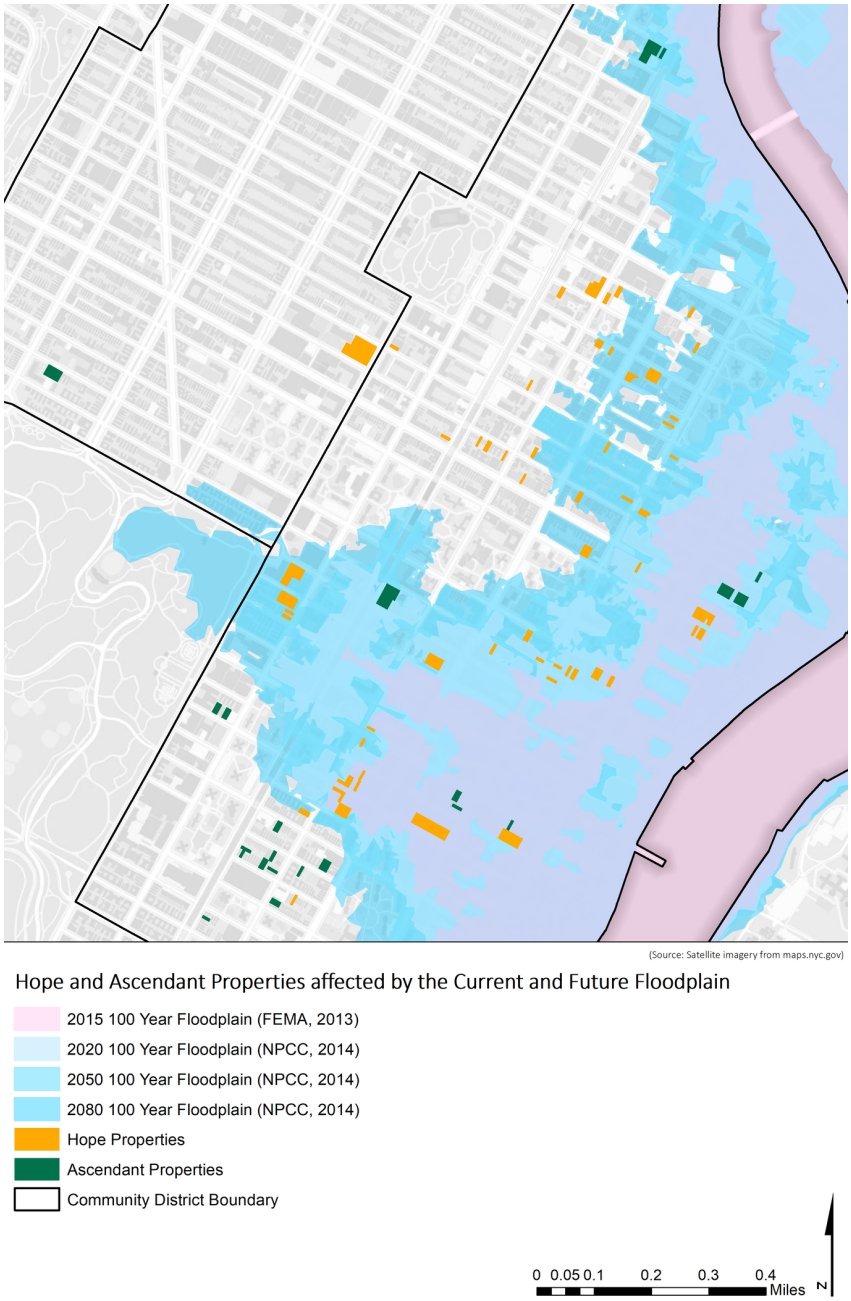

Figure 4: Hope and Ascendant Properties affected by the Current and Future Floodplain (Building-Block-Lot scale)

When compared to all the buildings in Central (3133) and East Harlem (4358), Fig. 5 shows that properties in East Harlem may flood at higher rates than those in Central Harlem. East Harlem shows percentages ranging from 29% of affected buildings in 2015 to 65% in 2080, whereas in Central Harlem the range goes from 1% in 2015 to 5% in 2080. Fig. 6 represents the same data in GIS.

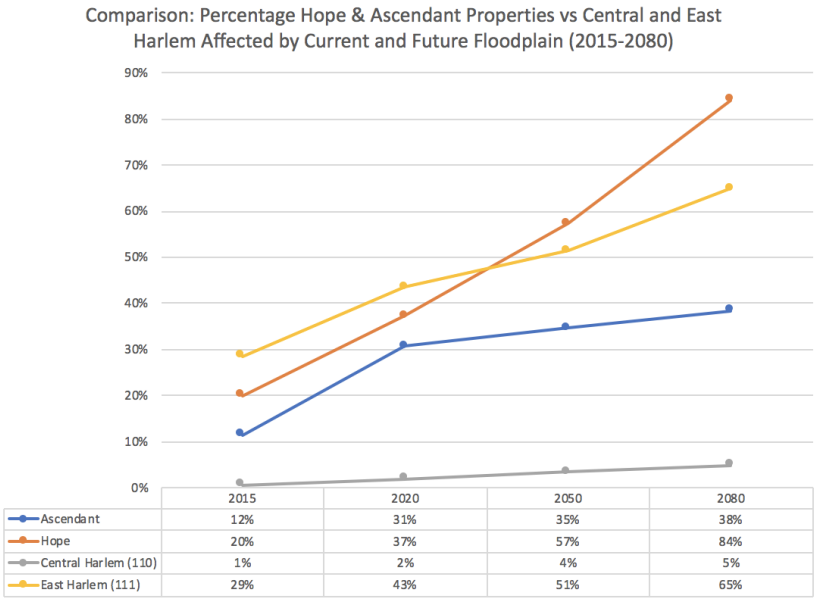

Figure 5: Comparison between all properties and current and future floodplain

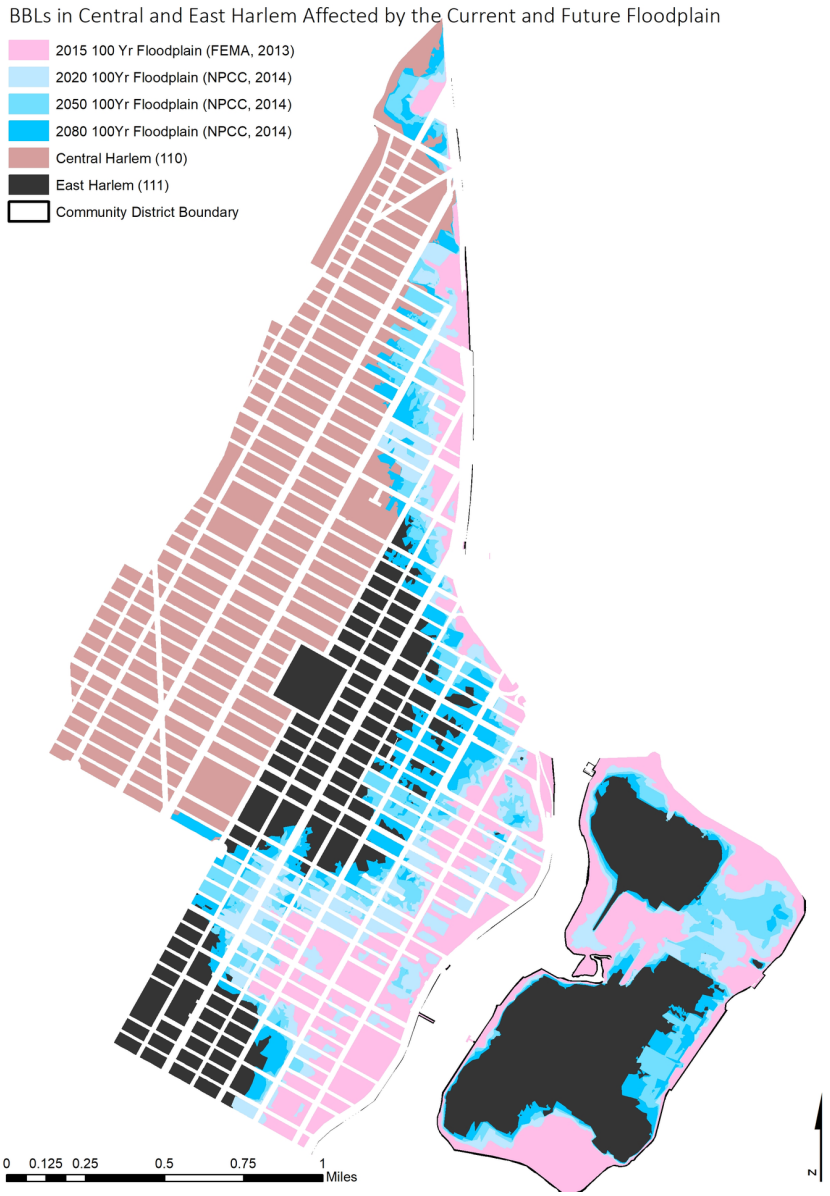

Figure 6: Buildings in Central and East Harlem affected by current and future floodplain (Building-Block-Lot scale)

The table below summarizes all the results so far, adding the yearly rate of change in flooded buildings. Hope's properties have a higher yearly rate of change (4.9%) than Ascendant's (3.6%) but this may be due to the fact that Hope has more properties (78) than Ascendant (26) in the sample. Aside from 2 properties owned by Ascendant, all the other properties fall within East Harlem. The yearly rate of change of Hope properties is also more than double than that of East Harlem (2%). Central Harlem's yearly rate of change is much higher (9.8%), because in 65 years the percentage of flooded buildings goes from 1% in 2015 to 5% in 2080. I conclude that Hope Properties may be more exposed to flooding under current and future floodplain than Ascendant Properties and may also be more exposed than all the building in East Harlem.

	Hope Properties	Ascendant Properties	Central Harlem	East Harlem
Total Number of Buildings	78	26	4358	3133
% flooded in 2015	20%	12%	1%	29%
% flooded in 2020	37%	31%	2%	43%
% flooded in 2050	57%	35%	4%	51%
% flooded in 2080	84%	38%	5%	65%
Yearly Rate of Change	4.9%	3.6%	9.8%	2%

The spatial statistics performed on the digital elevation model revealed that the average elevation of the buildings that may flood in 2015 is 7.9 feet, in 2020 it is 11.6 feet, in 2050 it is 10.8 feet and in 2080 14.4 feet. Those that never flood under any scenario (31 properties) have a diverse range of elevations, going from 12 feet to 60 feet. This means that other factors rather than elevation should also be taken into account, because the mean elevation calculated here takes into account the building parcel and not streets morphology. Fig. 7 represents the same data in GIS.

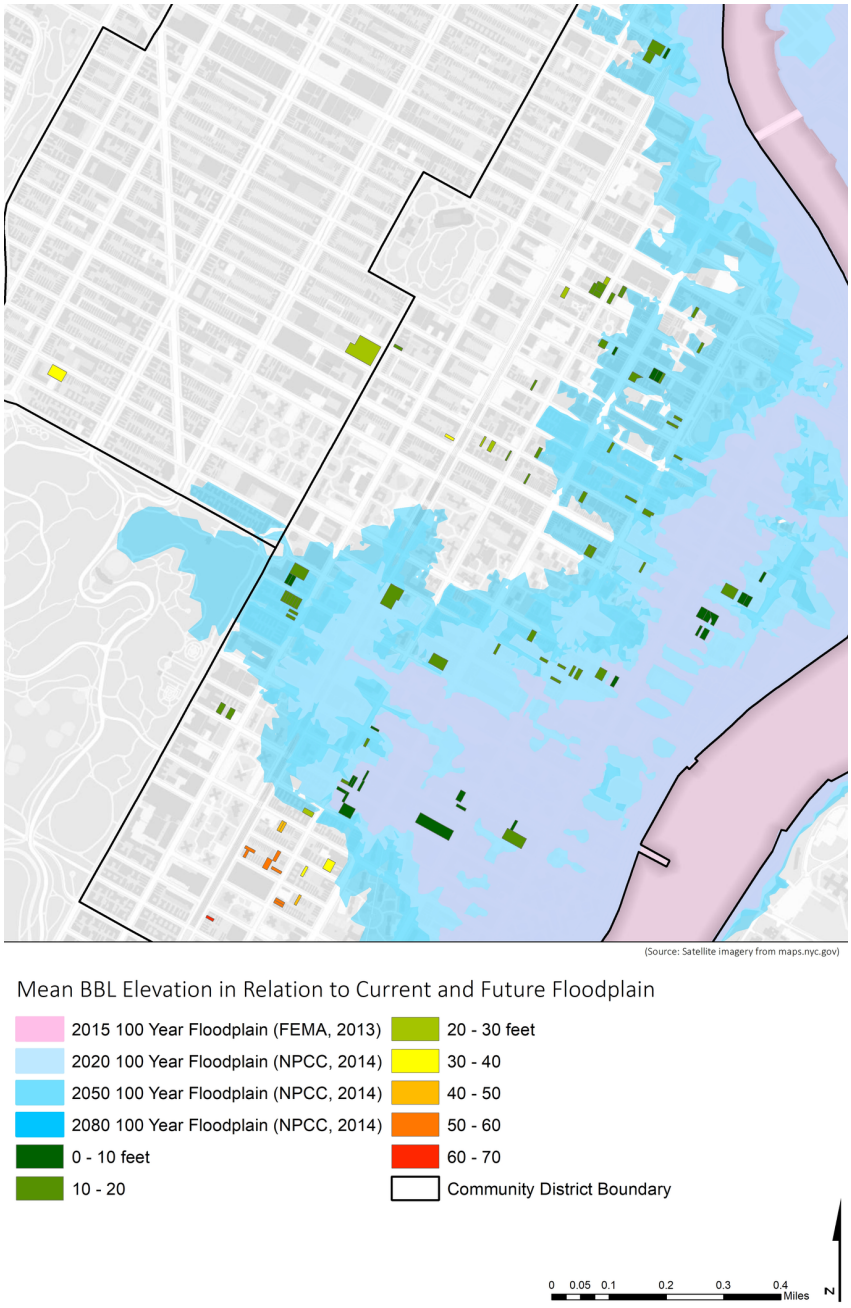

Figure 7: Mean Elevation of Hope and Ascendant Properties

The table below compares the elevation results between Borough, H&A properties and all the buildings in Central and East Harlem. A contributing factor to Hope Properties flooding more than Ascendants' is topographical elevation. Hope Properties are at lower median elevation (13.2 feet) than Ascendants (29 feet) and also lower than the median elevation of both Central (22 feet) and East Harlem (15 feet).

Elevation (in feet)	Manhattan (DCP, 2018)	Hope	Ascendant	Central Harlem	East Harlem
Mean	42.7	30	13.4	23.6	17.7
Median	27	13.2	29	22	15
Minimum	15	6.2	5.6	-	-
Maximum	103	66.4	43.8	-	-

Results from the Hot Spot Analysis, see Figure 8, shows that 541 out of 2844 (19%) of all East Harlem properties are within the 90-99% confidence level. More specifically 176 out of 2844 (6%) are at 95% and 185 out of 2844 (7%) are at 99%. This means that 19% of all residential units in East Harlem have a high degree of vulnerability to coastal flooding and the three socio-economic indicators included in this study.

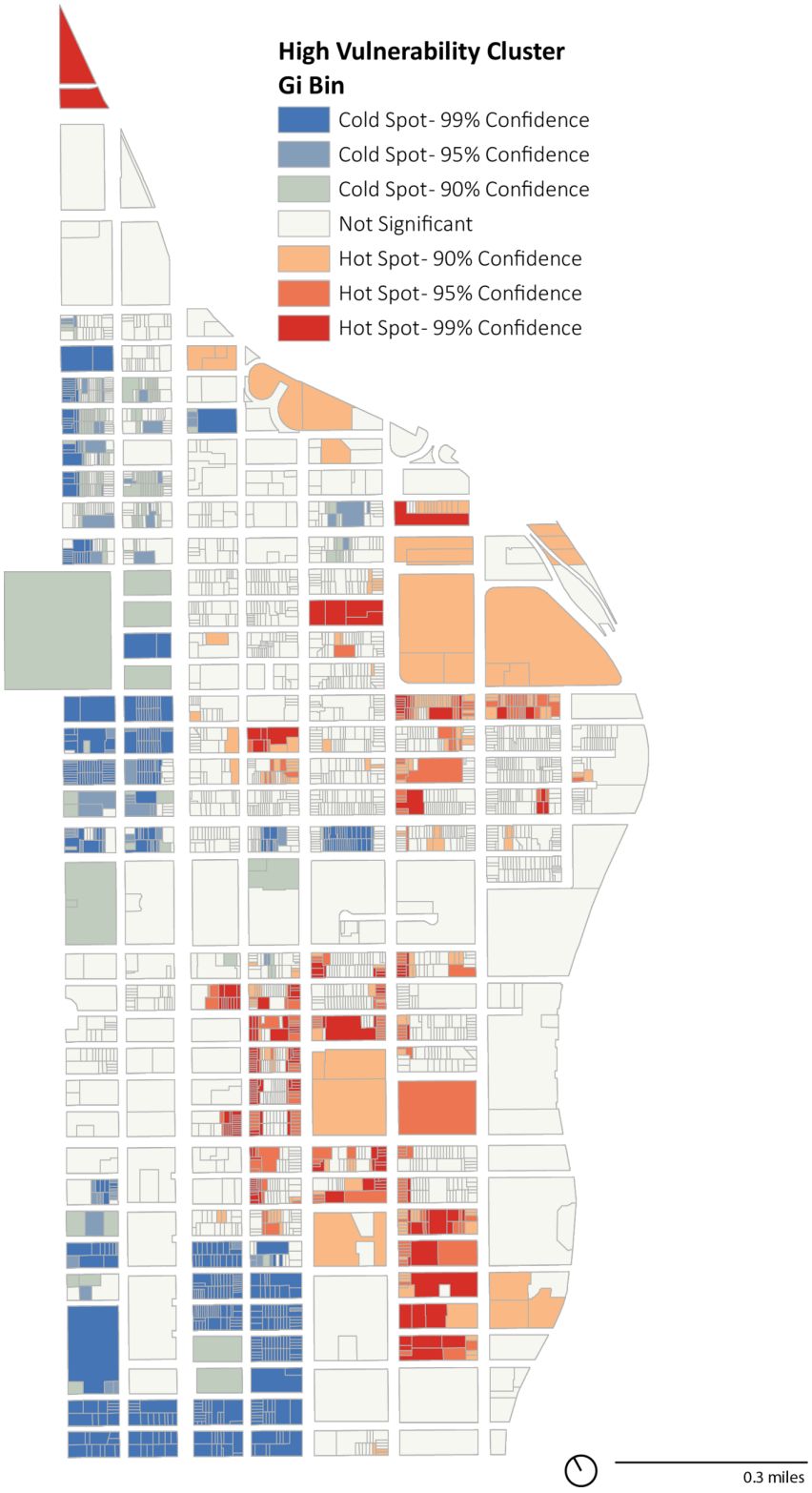

Figure 8: Hot Spot Analysis, showing clusters of low and high socio-economic vulnerability

NMC properties show higher vulnerability than all properties in East Harlem. 37 of 157 (24%)

of the NMC properties are within the 90-99% confidence level. More specifically 9 out of 157 (6%) are at 95% and 13 out of 157 (8%) are at 99% confidence level. Among those, 4 out of 28 of AND properties are at 90-99% confidence level, while of the 19 out of 78 of HOPE properties, are at 90-99% confidence level. Hope properties are not just more exposed to coastal flooding but they are also more vulnerable because their BBLs feature more among those that are affected by changes in rezoning, rent subsidy expiration and higher rates of low- income residents. Figure 9 highlights the polygons where both Ascendant and Hope and other affordable rental housing units owned by organizations in the NMC are located in relation to the socio-economic hot spot clusters.

Figure 9: Polygons of hot socioeconomic vulnerability where CDC owned properties are located

Discussion and Conclusions

Hope Properties are a peculiar case compared to the percentage of flooded buildings in East and Central Harlem under current and future floodplain, they are also more represented within hot spots of socioeconomic vulnerability.

This study opens up a series of relevant and timely questions about the future of private corporation owned affordable housing in NYC. CDCs owned properties are important for the city because lower-income people traditionally serviced by NYCHA or shelter housing are now both overcrowded. Also, as indicated New York city housing has been shifting in favor or more middle and high priced rentals, in a glaring erosion to the inventory of rent regulated housing.

Through this analysis we show that CDC owned housing may be affected by not only increasing rates of coastal flooding now and into 2080 but also by the compounded effect of changes in urban zoning and rent subsidy expiration, which can both affect the present and future viability of the CDCs' model. A loss of affordability in the private market is a loss of affordability for all.

The hot spots indicate the areas that, in the near future, may return a loss of affordable housing due to the multiple factors here studied. Cold spots, on the other hand, may be considered for expansion of CDC owned properties. Although rezoning is complex and may also bring positive effects, this study points to the need for rezoning plans that are more sensitive to affordability needs and climate resiliency needs across East Harlem.

Data Sources

Hope and Ascendant Properties (Hope and Ascendant, 2018)

Northern Manhattan Collaborative Properties (NMC, 2019)

Tax lot and Community Districts shapefiles (MapPluto, 2018)

2015 100 Year floodplain ('current') (FEMA, 2013)

2020 100 Year floodplain (10" SLR) (NPCC, 2014)

2050 100 Year floodplain (30" SLR)(NPCC, 2014)

2080 100 Year floodplain (58" SLR) (NPCC, 2014)

New York City Digital Elevation Model (1 foot) integer raster (NYC OpenData, 2018)

2017 East Harlem Rezoning (NYC Department of City Planning)

Satellite imagery and basemaps (www.maps.nyc.gov)

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