Climate gentrification and the role of flood insurance

An initial investigation into insurance risk, consumer costs, and resilience incentives under the stress of a changing climate in Broward and Miami-Dade counties

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In the United States and elsewhere, homeowners make long-term commitments to property ownership in order to raise families and to build wealth and social roots.

The 30-year mortgage is the backbone of the housing market, secured by hazard insurance. Thanks to the U.S. government's National Flood Insurance Program (NFIP) and a growing private flood insurance market, many homeowners are increasingly aware of flood risk and enjoy an expanding set of options to protect what is typically their largest investment. But homeowners are also increasingly aware of Earth's changing climate and its effect on several drivers of insurable risk, such as floods, hurricanes, and wildfires. Climate-related volatility in these perils operates both globally and locally, manifesting in physical changes such as sea level rise and increased average precipitation from tropical storms. Those phenomena, in turn, impact storm surge and inland flooding risk.

The visibility of climate's impact on property hazard is increasingly leading individuals and their chosen leaders to ask: how might an increase in hazard affect the desirability of living in various communities, and how do we manage the socioeconomic impacts? Recent news stories have highlighted the concerns of "climate gentrification," or potential migration from low-lying but relatively well-off areas to areas of higher elevation but sometimes higher poverty.[1] At Milliman, we view the problem through the lens of managing shifts in insurable property value at risk and economic incentives associated with insurance costs.

For this article, we worked with Jupiter Intelligence, a climate risk analytics provider of forward-looking and probabilistic hazard data for future conditions, to develop a framework for analysis that may spark insights for community leaders in the public and private sectors who are charged with managing change and planning for a resilient future.

Defining the risk: A workable classification of at-risk communities

For this pilot study, we chose to investigate a region of Southeast Florida, spanning parts of Miami-Dade and Broward counties. This area represents a "climate crucible," associated with the following characteristics:

- A mostly urban, highly populated area
- An unusually varied range of income levels
- Experiencing documented sea level rise[2]
- Subject to a known extreme level of quantified, mapped flood hazards associated with Atlantic hurricanes

Our plan for studying climate gentrification risk starts by defining four quadrants for mapping the region:

1. ***Stable*** areas of relatively high ground,[3] encompassing mostly communities with relatively high incomes.
2. ***Emigrating*** areas of relatively low ground, encompassing mostly high-income communities.
3. ***Destination*** areas of relatively high ground, currently populated mostly by low-income communities.
4. ***Crisis*** areas that face high flood risk in extreme events, yet are mostly populated by low-income communities.

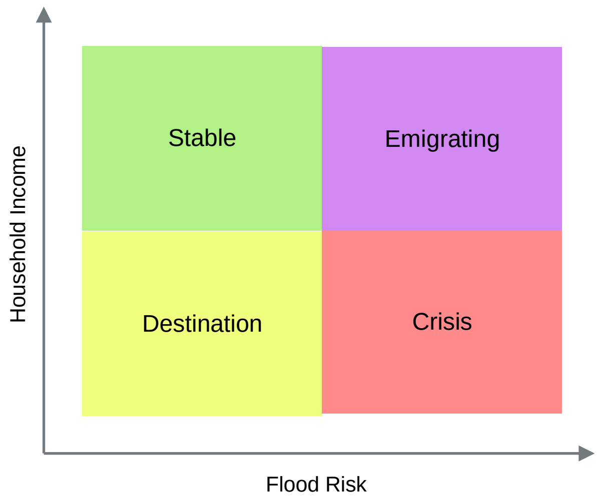
[1] Harris, A. (December 28, 2018). Climate gentrification: Is sea rise turning Miami high ground into a hot commodity? Miami Herald. Retrieved September 11, 2019, from https://www.miamiherald.com/news/local/environment/article222547640.html.

[2] The Unified Sea Level Rise Projection report, published by the Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group, states in part: "In the short term, sea level rise is projected to be 6 to 10 inches by 2030 and 14 to 26 inches by 2060 (above the 1992 mean sea level). In the long term, sea level rise is projected to be 31 to 61 inches by 2100." The report is available at http://southeastfloridaclimatecompact.org/wp-content/uploads/2015/10/2015-Compact-Unified-Sea-Level-Rise-Projection.pdf.

[3] More precisely, low risk of inundation beyond a given threshold depth in extreme event scenarios, as defined by Jupiter and Milliman using Jupiter's technology.

A visual representation is provided in the chart in Figure 1.

FIGURE 1: QUADRANTS FOR GENTRIFICATION STUDY



How were these regions quantified? First, Milliman used the U.S. Census estimates of poverty status by household at the geographic resolution of Census Block Group (CBG)[4] to determine relative income distribution across the region—likely a better measure of the potential for migration than absolute income. Using the statewide CBG data, we defined the bottom quartile of CBGs—the 25% of CBGs having the highest proportion of households living below the poverty line—as "low income." Remaining CBGs were defined as "high income."

Next, we defined a geographic measure of hazard risk within the region. Jupiter provided a geospatial data set indicating modeled flood inundation extents for areas experiencing greater than one-foot water depth for a flood with a 1% annual chance of occurrence (1-in-100-year flood event) under a "high" sea level rise scenario,[5] estimated for the year 2050. Jupiter's model output incorporated the combined probability of flooding caused by storm surge from tropical cyclones, seasonal high-tide flooding, precipitation, and the resulting overland and riverine flooding. Jupiter's technology and implementation of current climate science is described further in the sidebar.

The final step in mapping the region into quadrants was to track the intersection of income levels by CBG and future flood hazard. Any given land area in the region thus fell into one of four classifications: high-income/low-hazard, low-income/low-hazard, high-income/high-hazard, or low-income/high-hazard. We use the Stable, Destination, Emigrating, and Crisis keywords, respectively, as descriptors for this article.

Notably, the goal of this study is to define a methodology and framework for extracting insights that are not overly dependent upon the sources for either income or hazard data. Jupiter is among a number of private and public sector organizations that continue to advance our understanding of physical climate risk at a local level. In addition, while the U.S. Census is an excellent source for U.S. income data, other data could be used to define relative socioeconomic status. Our methodology was designed so that such model inputs could "plug and play" with our approach.

Actionable insights from climate science

Jupiter's role in the study is to bring together the latest climate modeling methodologies and scientific research to provide actionable insights for climate resilience. Beginning with the consensus Intergovernmental Panel on Climate Change (IPCC) representative concentration pathways (RCPs) for future greenhouse gas (GHG) emissions, Jupiter provides probabilistic modeling of an expansive set of planetary responses, such as storm surge, precipitation, and ocean/tidal dynamics as a result of each emissions scenario that captures extreme events in the future. Modeling is based on state-of-the-art dynamics augmented with machine learning, resulting in probabilistic geospatial data that capture the non-stationarity (changing extremes in addition to changing mean states) of our climatic system while fully accounting for uncertainty to better inform risk management. Those data are then combined into peril-based reporting on, for example, flood, heat, wind, etc., to enable analysis of physical risks associated with extreme events in a changing climate.

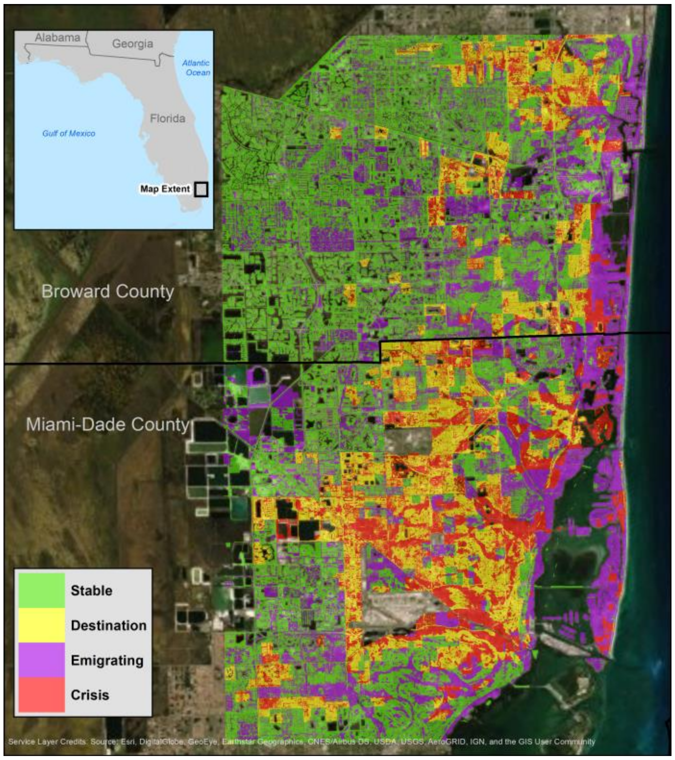
[4] U.S. Census Bureau (2018). 2013-2017 American Community Survey 5-Year Estimates, Table B17017: Poverty Status in the Past 12 Months by Household Type by Age of Householder. Accessed via ACS Summary File.

[5] This regionally specific sea level rise scenario corresponds to a scenario resulting in 2.0 meters of global average sea level rise by the year 2100. It is roughly consistent with the Intergovernmental Panel on Climate Change (IPCC) RCP8.5 emissions scenario, which is expected to result in global temperature increases of 2.6 to 4.8 degrees Celsius relative to current global temperature. It represents persistent global emission growth and no additional efforts to reduce emissions beyond those already in place. This high sea level rise scenario includes physically plausible and higher-end estimates of sea level rise from melting polar ice sheets and warming oceans.

Examining the regional gentrification risk profile

Even prior to the introduction of any insurance-specific data, we found the quadrant mapping results insightful. The map in Figure 2 shows the results of combining the Jupiter and U.S. Census Bureau data to generate the Stable (green), Emigrating (purple), Destination (yellow), and Crisis (red) areas.

FIGURE 2: CLIMATE GENTRIFICATION RISK QUADRANTS FOR THE STUDY REGION



Residents from a large swath of coastal upscale communities and suburban neighborhoods in Broward and Miami-Dade counties (purple Emigrating areas) may face incentives to emigrate to more urban land areas closer to city centers. A collar of northwestern and western neighborhoods are likely to be relatively unaffected, but several distinct pockets across the region, particularly in Miami-Dade, contain mostly lower-income communities that are most at risk from climate-influenced extreme weather. These Crisis areas, adjacent to rivers, canals, and the coastline, will likely be least able to adapt given their socioeconomic status.

What are the implications for insurable value at risk?

Our next step involved using Milliman's flood insurance Market Basket data set[6] for Florida to estimate the total number of owner-occupied residences and insurable value at risk within the study region. Using the precise latitude and longitude of each Market Basket location in conjunction with the quadrant map layer shown in Figure 2, we calculated the number of Market Basket households and concomitant insurable value within all the land area making up each quadrant. Then we used the publicly available data set of total insured residential households reported to the Florida Hurricane Catastrophe Fund (FHCF) at the ZIP Code level to gross up the totals within each quadrant to approximate market-wide levels.[7] The results are in the chart in Figure 3.

A significant proportion of the population and insurable value in the region resides in the Emigrating quadrant. To the extent consumer awareness of climate-driven increases in hazard incentivizes gentrification, the emigrants would likely be moving toward a smaller land area in the Destination quadrant, which

FIGURE 3: ESTIMATED INSURABLE VALUE AT RISK AND NUMBER OF HOUSEHOLDS BY QUADRANT

QUADRANT	OWNER-OCCUPIED HOUSEHOLDS	% OWNER-OCCUPIED HOUSEHOLDS	TOTAL INSURABLE VALUE AT RISK (BILLIONS)	% TOTAL INSURABLE VALUE
Stable	**153,718**	**45.8%**	**$33.232**	**48.0%**
Emigrating	**91,630**	**27.3%**	**$19.568**	**28.2%**
Destination	**50,654**	**15.1%**	**$9.189**	**13.3%**
Crisis	**39,444**	**11.8%**	**$7.314**	**10.6%**

6 Milliman's Market Baskets are sets of data points representing precise locations of known properties and a sample percentage of the actual number of properties available to insure. The property attributes for the locations are hypothetical and balanced to reflect observed patterns in each region for key characteristics such as amount of insurance coverage, insurance deductible, square footage of living area, year of construction and renovation, wind and flood loss mitigation features, and other elements important for insurance premium rating.

7 The exposure at the ZIP Code level is only available upon request in a data file, but the amount of exposure by "rating region" (25 noncontiguous groups of ZIP Codes) is shown in Exhibit XV of the FHCF Ratemaking Formula Report, available at https://www.sbafla.com/fhcf/Portals/FHCF/Content/AdvisoryCouncil/2019/20190319_FHCF_RatemakingFormulaReport.pdf?ver=2019-03-20-091149-383.

currently comprises less insurable value, and driving up property values in these areas. Of course, some migration will be out of the region altogether. Demographic change from emigration may also occur in the Stable quadrant. Over time, the impact on population density and insurable value from gentrification is likely to have urban planning implications.

Note that over one-tenth of the households and insurable value in the region reside in the Crisis quadrant. A number of families are at serious risk of increasing flood hazard, yet may have few options for loss mitigation or migration given their socioeconomic status. This result could drive discussions among area leaders charged with disaster preparedness and economic growth.

How might flood insurance costs amplify or dampen gentrification incentives?

Our final task in this investigation was to apply the rating algorithm for the NFIP to the Market Basket to generate estimated NFIP premiums for each property. These premiums depend on the unique geographic framework of "flood zone" as defined by the NFIP,[8] as well as certain property attributes such as first floor height (expressed as the difference from a "base flood elevation") and year of construction. We are most interested in whether average flood insurance premiums in quadrants ripe for emigration and resettlement may reflect an economic incentive for gentrification.

One measurement problem is that high-income households tend to have more valuable homes, so the premiums are converted to rates per $1,000 of insurable value, in an attempt to approximate the core level of flood risk.[9] Additionally, the NFIP only offers a maximum of $250,000 of dwelling coverage regardless of the home's actual value, offers no loss of use coverage, and offers limited coverage for personal property (maximum of $100,000) and other structures on premises. Measuring the average rate using NFIP premium against the full value of the home mismatches the premium and coverage for larger homes, but gives some insight into the degree of affordability among the quadrants. On the other hand, measuring the average rate against the limited value of the home ($250,000 or less) gives a better picture of the core hazard risk estimate underlying the premium. In the chart in Figure 4, we show the average flood insurance rate across each quadrant, relative to both the full and limited home value.

The results are striking in two ways. First, the average flood rate against full home value is notably lower in the Emigrating (higher-risk, higher-income) quadrant than in the Destination quadrant. This suggests a potential geographical mismatch between the NFIP's current rating plan and local flood risk, one that may be exacerbated by climate trends. The NFIP has announced that its Risk Rating 2.0 initiative, which revamps the actuarial rating plan, will be rolled out in Florida starting in 2020. The effects on alignment of premium and risk are as yet unknown, but may have an impact on gentrification incentives.

Second, the relationships reverse when the full value of the home is replaced by the value limited to the NFIP's maximum coverage amount. This difference indicates that current federal flood insurance prices may also be imperfect risk signals due to limitations in coverage amounts. The difference is largest within the Emigrating quadrant, indicating that distortions are most prevalent in a quadrant with generally larger homes and higher flood risk. While Risk Rating 2.0 intends to address the actuarial problem of "insurance-to-value," the current situation may obscure risk signals that would otherwise incentivize gentrification.

FIGURE 4: NFIP RATES PER $1,000 OF INSURABLE VALUE BY QUADRANT, LIMITED AND NOT LIMITED

QUADRANT	OWNER-OCCUPIED HOUSEHOLDS	% OWNER-OCCUPIED HOUSEHOLDS	TOTAL INSURABLE VALUE AT RISK (BILLIONS)	% TIV	AVERAGE NFIP RATE (PER $1,000)	AVERAGE NFIP RATE LIMITED (PER $1,000)
Stable	**153,718**	**45.8%**	**$33.232**	**48.0%**	**2.12**	**2.69**
Emigrating	**91,630**	**27.3%**	**$19.568**	**28.2%**	**2.43**	**3.61**
Destination	**50,654**	**15.1%**	**$9.189**	**13.3%**	**3.02**	**3.15**
Crisis	**39,444**	**11.8%**	**$7.314**	**10.6%**	**3.82**	**4.20**

[8] Definitions of NFIP flood zones are publicly available at https://www.fema.gov/flood-zones.

[9] The approximation is distorted by the fact that current NFIP premiums are not fully reflective of "insurance-to-value." In brief, less valuable homes pay more than they should, and more valuable homes pay less, from an actuarial viewpoint. This problem will be addressed in the NFIP's Risk Rating 2.0 rating plan.

Going forward: Scaling the approach to larger areas and more scenarios

Census income data is available nationwide and frequently updated, but suitable flood inundation maps across the United States are less widely available. The combined risk of flooding from riverine overflow (fluvial), excessive precipitation (pluvial), and storm surge action is available only when all of these perils are included in the hazard generation model. It will take significant work to model future flooding scenarios on a national scale that incorporate varied time horizons, probability levels, flooding sources, and a range of scientifically plausible climate trends. Jupiter's capabilities advanced our understanding significantly within the study region, and we look forward to more tools coming online at scale that will facilitate joint discussions of the insurance, social, and economic implications in more places, given the underlying science.

That said, our general approach to assessing insurance-influenced socioeconomic impacts of climate gentrification is applicable and scalable to many regions. Flood premiums for the NFIP and some private insurers can be estimated for properties anywhere in the United States, and Milliman's Market Baskets are available for the 48 contiguous states. Eventually, as populations grow and development progresses, the approach could be modified to address other hazards, such as wildfires in the wildland-urban interface. As the science, technology, and methodologies improve, we envision providing local leaders, investors, insurers, and planners an enhanced perspective on the climate-related factors that may drive intake of new residents, migration of current residents, and emergency management demands on hard-hit communities.

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