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How Much Danger? A Comparison of Alternative Measures of Flood Hazards Across the Third Federal Reserve District States

COMMUNITY DEVELOPMENT & REGIONAL OUTREACH

Lei Ding, Theresa Dunne, George C. Galster, and Joshua C. Galster

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Introduction

Flooding is the worst natural hazard in the United States, as measured by property damage. The Federal Emergency Management Agency (FEMA) maintains and updates flood maps to support the National Flood Insurance Program (NFIP), designed to protect homeowners and renters against flood-related financial losses. Properties located in FEMA-designated Special Flood Hazard Areas (SFHAs) are subject to more stringent building codes and are required to carry flood insurance if they have federally backed mortgages, although there is disagreement regarding the actual enforcement of the insurance requirement (GAO 2021). Because of the crucial role the FEMA SFHA approach plays in preventing and mitigating losses from flooding, it is important that the SFHA measure provides up-to-date, comprehensive, and consistent measures of flood hazards across the nation.[1]

This brief compares flood hazard estimates from the well-established FEMA SFHA method with a new, alternative flood hazard measure developed by the First Street Foundation (FSF). The goal is to have a more complete understanding of the properties in danger from flooding and to evaluate whether the resulting predictions of exposure and potential losses differ across communities of different incomes and racial/ethnic compositions. By no means does this brief intend to evaluate which measure is better. Rather, this brief seeks to identify communities where the two different flood hazard measures agree and to understand the implications for property owners and residents in less advantaged communities when the two measures disagree.

Specifically, we address the following research questions:

1. Where do the FEMA and FSF measures align in identifying properties that bear substantial danger of flooding in Third District states?

2. Are the differences in flood danger assessments systematically related to their coastal or noncoastal location,[2] and the income and racial/ethnic composition of neighborhoods?

We find that both the FEMA and FSF measures are highly correlated for properties that face a high hazard from flooding in higher-income and majority-White neighborhoods, especially in coastal areas in the Third District states.

- The FEMA and FSF designations are less correlated in noncoastal areas, especially in lower-income noncoastal communities.

- The FSF's measure tends to identify more properties in noncoastal and lower-income neighborhoods with higher pluvial flood hazards (i.e., flooding from rainfall), whereas FEMA's tends to point more toward coastal and higher-income neighborhoods as areas with higher flood hazards.

Findings from this brief should help policymakers and practitioners understand the vulnerability of different communities to floods and develop better targeted community disaster resilience and mitigation strategies. This research is part of the Federal Reserve's ongoing work to promote economic growth and financial stability for low- and moderate-income (LMI) individuals and communities.

How Did We Make the Comparison?

FEMA uses the Flood Insurance Rate Maps (FIRMs), commonly referred to as floodplain or flood zone maps, to support the NFIP program to mitigate and reduce comprehensive flood risk. SFHAs are flood zones identified on the FIRMs that would be inundated by a one-in-100-year flood. FEMA usually performs a Flood Insurance Study (FIS) to determine a community's exposure to flood hazards.[3] SFHAs are created for individual communities from a set of hydrologic models using historical river discharge data as well as past flood indicators, such as high-water marks and aerial photographs (GAO 2021).

A comparable measure developed by the FSF can also identify whether a property faces at least a 1 percent annual probability of flooding that amounts to a depth of at least 5 centimeters. The FSF's 1 percent flood probability measure produces property-level estimations by modeling various types of flooding — pluvial (flooding from rainfall independent of a body of water), fluvial (flooding from a river, lake, or stream overflowing its banks), and tidal/coastal — and using current precipitation and land use conditions, among other factors (Bates et al. 2021).

[1] In this brief, we follow conventional practice and use the terms "exposure" or "hazard" to refer to the probability that a flood will occur, and "risk" to mean the expected financial losses associated with a flood.

[2] Properties in coastal and noncoastal tracts are analyzed separately in this brief for two reasons. First, flooding outcomes can vary greatly depending on a census tract's proximity to the coast. Second, coastal areas possess attractive amenities associated with water proximity that may offset the flood hazards at least partially. A census tract is defined as coastal if its boundary intersects the national shoreline as outlined by the National Oceanic and Atmospheric Administration: shoreline.noaa.gov/data/datasheets/medres.html.

[3] See more details on how FEMA performs a Flood Insurance Study to determine a community's risk to flood hazards here: www.fema.gov/flood-maps/change-your-flood-zone/status/flood-insurance-study.

Both the FEMA SFHA measure and the FSF 1 percent hazard measure identify properties with a 1 percent or higher annual probability of flooding, so they are generally comparable. They do, however, differ in important ways.

First, the FEMA SFHA approach does not identify all flood hazards. Exposure to pluvial flooding, or flooding from rainfall, which is considered by the FSF's flood modeling, is not currently covered by the FEMA FIRMs when deciding where SFHA zones are (GAO 2021). As a result, properties bearing a significant probability of pluvial flooding (but not having substantial fluvial or tidal flood exposures) may be more likely to be captured by the FSF measure than by the FEMA measure.

Second, FEMA has been relying on a "bottom-up" approach, in which communities can choose to participate in the NFIP or not. Those living in nonparticipating communities do not have access to flood insurance under the program, and the flood mapping by FEMA requires significant resources and time, making it difficult for the NFIP program to cover the whole nation.[4] Furthermore, updating the FEMA floodplain maps is often a community-driven effort, in which communities notify the agency of changes in local flood hazards and provide relevant data needed to update the NFIP maps (Knighton et al. 2018; Weill 2023). The FSF approach, in contrast, is based on flooding hazard models, allowing for a more spatially extensive coverage of flood exposures across the nation. Some areas, like smaller waterways or remote communities, thus may be less likely to be mapped by FEMA, and even if they are mapped, the maps could be of different levels of quality (Wing 2017; Pralle 2019; GAO 2021; Guin 2023; Weill 2023).

Third, FEMA designed FIRMs to reflect existing conditions, and the FEMA maps could be of different ages in some communities, although the agency is required to review a community's flood map every five years and then determine whether to update the maps (FEMA 2023). Thus, flood hazards from ongoing or future development and climate change are less likely to be captured by the FEMA measure, and SFHAs may not necessarily reflect how flood hazards will change (GAO 2021). On the other hand, the FSF performs major updates to its data on an annual basis by incorporating new property or elevation data and rerunning the models.

As a result, the coverage of FEMA SFHAs is likely more limited than the FSF model, which is documented by multiple studies trying to provide a more comprehensive and consistent analyses of flood hazards across the United States (e.g., Amodeo et al. 2020; Wing et al. 2022; Weill 2023). Keeping all these caveats in mind, even the First Street Foundation (2020) acknowledges that FEMA flood mapping is the "gold standard" for understanding flood hazards in the United States. The challenge is that local precision comes at the cost of scale and the inclusion of pluvial flood hazards, sea level rise, and ungauged streams should be responsible for most of the additional exposure identified by the FSF.

TABLE 1 **Flooding Hazards and Corresponding Indicators Included in the Analysis**

Hazard Type	Indicator	Definition
FEMA flood zone	FEMA's Special Flood Hazard Area (SFHA)	Indicates whether a property is in a FEMA SFHA, which is an area FEMA designates as facing at least a 1 percent annual probability of flooding.
FSF exposure	1 percent annual probability of flooding	The probability of a property experiencing at least one flooding event that meets or exceeds the 5 centimeter threshold in Year 0 (2022) is 1 percent or higher. Threshold depths are relative to ground elevation, regardless of if there is a structure present on the property.
Current risk	Average annual loss per property	A property's expected repair costs (not structure value lost) due to flood damage in Year 0 (2022), based on FSF's median modeling output. The annual loss value is missing in the data if there is no property present on the property or if the property falls outside of the modeled area.
Flood source	Flood source	Indicates the primary source of flooding, either fluvial, pluvial, or tidal/coastal surge.

Sources
Climate Data via First Street Foundation

[4] The U.S. Environmental Protection Agency estimates that FEMA mapping covers only about 60 percent of the contiguous United States and may not represent headwater areas and smaller floodplains. See details at catalog.data.gov/dataset/enviroatlas-estimated-floodplain-map-for-the-conterminous-united-states1.

A comparison of these two measures has important implications. Owners of residential properties inside FEMA SFHA 100-year flood zones are required to purchase flood insurance for properties with government-backed home loans. In contrast, while owners of properties in areas outside FEMA SFHAs can purchase flood insurance voluntarily, the actual take-up rates are very low,[5] since people usually do not purchase flood insurance unless they are forced to. So, a building inside a SFHA largely becomes a binary "in" or "out" proposition for lenders' and property owners' flood insurance decisions,[6] which affects not only whether flood insurance is compulsory or voluntary but also the price of insurance and the owners' and communities' awareness and attitudes toward flood risk.

See Table 1 for a summary of the outcome measures used in this brief derived from the property-level FSF data.

The Congruence of FEMA and FSF Assessments of Flood Danger

Our sample from the FSF contains nearly 9.6 million properties,[7] both residential and nonresidential, in Pennsylvania, New Jersey, and Delaware. We first examine the degree to which sets of properties flagged as facing substantial flood hazard by the FEMA and FSF indicators overlap. Almost 1.3 million properties are identified as having 1 percent or greater annual probability of flooding by either the FEMA or the FSF measures, about one-third of which (about 446,000 properties) are identified as being in danger by both measures. The number and share of properties that are located in SFHAs and are also identified by the FSF hazard measure

TABLE 2 **Properties in the Third District Within FEMA SFHAs and FSF 1-percent Annual Probability of Flooding, by State, Coastal/Noncoastal Areas, Income Status, and Majority Race/Ethnicity**

	Third District States			Pennsylvania		New Jersey		Delaware	
	Total	Noncoastal	Coastal	Noncoastal	Coastal	Noncoastal	Coastal	Noncoastal	Coastal
Total properties	9,558,955	8,403,031	1,155,924	5,578,108	134,034	2,561,853	862,071	263,070	159,819
Properties within FEMA SFHAs and with FSF 1 Percent Chance of Flooding									
Number of properties	446,622	213,884	232,738	156,333	4,159	55,551	206,586	2,000	21,993
% of properties	4.7%	2.5%	20.1%	2.8%	3.1%	2.2%	24.0%	0.8%	13.8%
By tract income									
Low- and moderate-income	4.2%	2.6%	15.3%	2.7%	3.1%	2.5%	19.8%	0.7%	10.6%
Middle- and upper-income	4.8%	2.5%	21.6%	2.8%	3.1%	2.1%	25.0%	0.8%	14.5%
By tract majority race/ethnicity									
Majority People of Color	2.7%	1.5%	10.0%	0.9%	3.0%	2.2%	12.9%	0.5%	5.6%
Majority Non-Hispanic White	5.1%	2.8%	22.8%	3.1%	3.2%	2.2%	26.6%	0.9%	15.4%

Sources
Authors' calculation based on Climate Data via First Street Foundation and the 2022 FFIEC Census Flat File.

[5] Bradt et al. (2021) suggests the take-up rates in areas outside SFHAs was only about 2.2 percent nationally in 2019, far below the 48.3 percent take-up rates inside SFHAs.

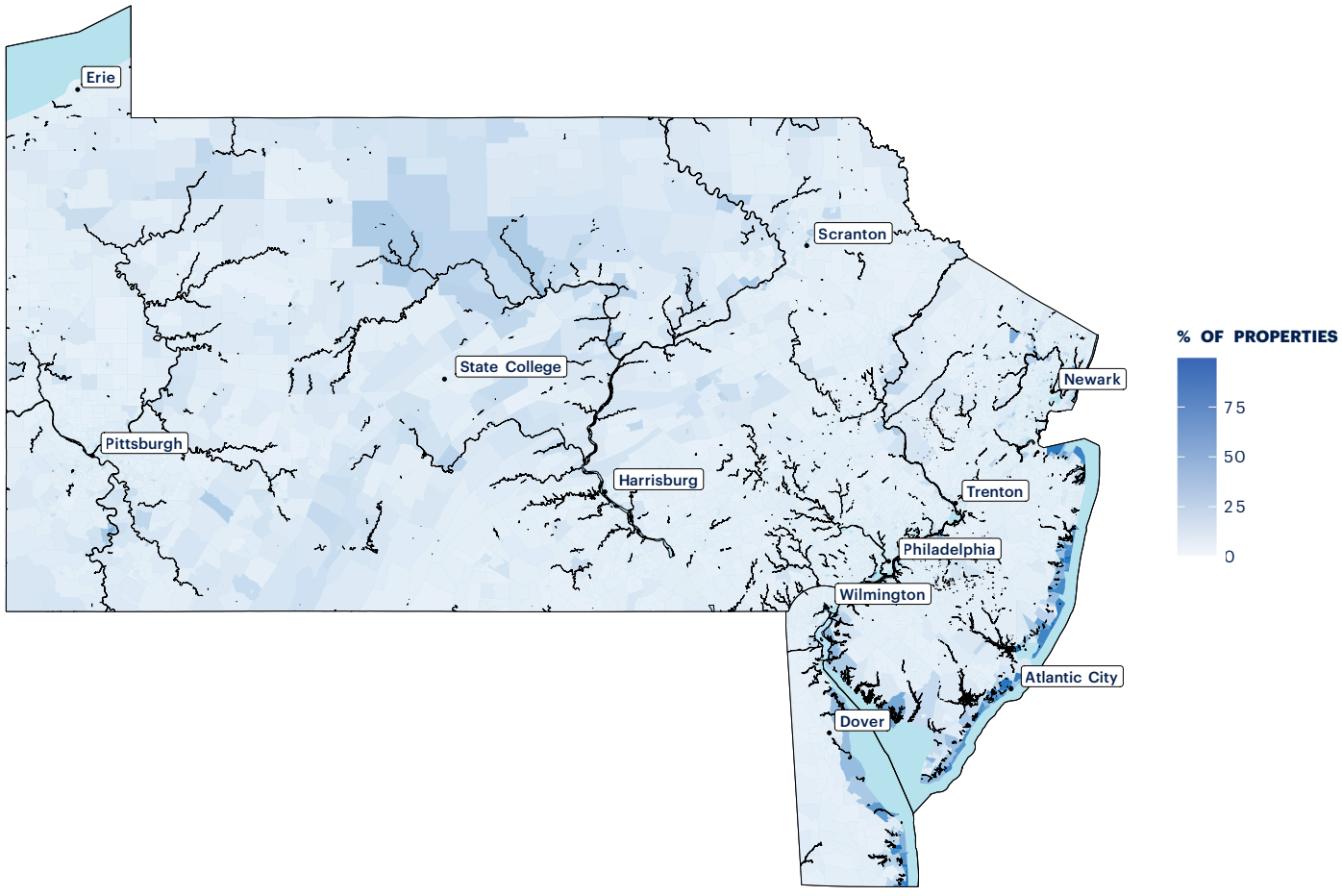
[6] FEMA's new flood insurance rating methodology, Risk Rating 2.0, does not redefine what SFHA zones actually are, although it helps adjust pricing of insurance premiums in existing FEMA SFHAs (Bradt et al., 2021).

[7] Note that the FSF does not distinguish among vacant and occupied buildings.

are presented in Table 2 and Figure 1. Results for properties identified by individual measures are summarized in Table A1 and A2 in the Appendix for Third District States and MSAs, respectively.

It is obvious from Table 2 that the share of properties in danger of flooding is far greater in coastal areas than in noncoastal areas in the three states, at 20.1 percent in coastal areas versus 2.5 percent in noncoastal areas. When these shares are compared across groups of census tracts distinguished by their income and racial/ethnic composition, higher percentages of properties with flood hazards are located in middle- and upper-income (MUI) census tracts than LMI tracts in coastal areas (21.6 percent versus 15.3 percent), and in majority-White census tracts than in majority people of color (POC) ones for both coastal and noncoastal parts of the Third District states.[8] The only exception is that in noncoastal areas, the difference between LMI and MUI communities is marginal (2.5 percent for MUI communities and 2.6 percent for LMI communities). Properties facing flood hazards as identified by both measures are more concentrated in MUI census tracts than LMI tracts in coastal areas and in majority-White census tracts than in majority-POC tracts in both coastal and noncoastal areas. Properties with government-backed mortgages in these MUI and majority-White neighborhoods thus are more likely to be covered by flood insurance.

FIGURE 1 **Share of Properties with an Annual Chance of Flooding >= 1 Percent by Both the FSF and FEMA SFHA Measures Across Third District States**



Sources
Authors' calculation based on Climate Data via First Street Foundation.

[8] Median household income data were retrieved from the FFIEC's 2022 Census Flat File, and census tracts are categorized as either LMI, where the median family income is less than 80 percent of the area median, or MUI, where the median family income is at least 80 percent of area median. From the same source, we categorized census tracts by whether they had a majority of non-Hispanic White or POC residents. The FFIEC Census Flat File accessed at https://www.ffiec.gov/censusapp.htm.

Incongruence of FEMA and FSF Assessments of Flood Danger

Figure 2 further compares the FEMA and FSF assessments of flood danger in Third District states, in terms of the shares of properties for which both measures either agree or disagree, in coastal and noncoastal areas. The FSF measure identifies a much larger number than the FEMA approach: the FSF measure designates 1,099,532 properties as facing substantial flood hazards (11.5 percent of the total), compared with a smaller number inside FEMA SFHAs — 639,583 properties (6.7 percent). In addition to the 4.7 percent of properties for which both measures of flood hazards agree, the FSF measure identifies an additional 6.8 percent of properties, which is consistent with the notion that the FSF model provides more complete flood exposure estimates and covers more types of flood hazards than the FEMA approach, as discussed earlier. Figure 2 demonstrates that FEMA and the FSF are much more congruent in their designations of which properties face significant flood hazards in coastal areas: 20.1 percent of all properties are consensually indicated by both, with almost four-fifths of FSF-identified properties being inside FEMA SFHAs and close to three-quarters of properties inside FEMA SFHAs also captured by the FSF measure.

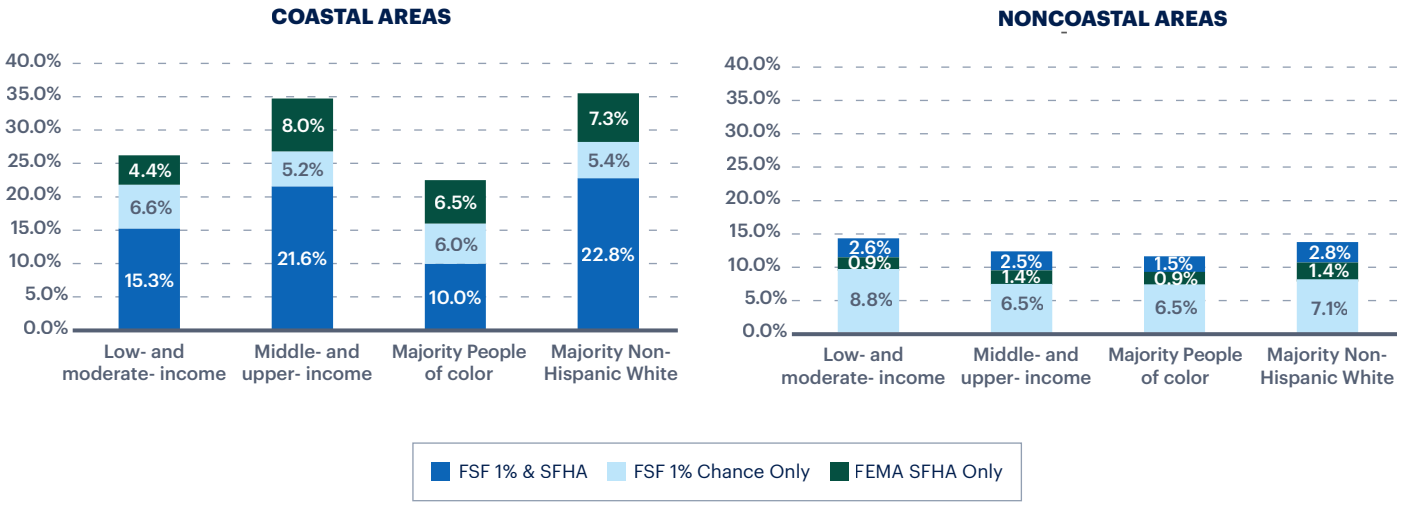
The FSF 1 percent probability approach identifies a significant number of additional properties not in SFHAs, especially in noncoastal areas. Out of the total 9.6 percent of properties identified by the FSF measure in noncoastal areas, only 2.6 percent fall inside the boundaries of SFHAs. In other words, almost three-quarters of FSF-identified properties in noncoastal areas in Third District States are not covered by FEMA SFHA 100-year flood zones that are used to determine if residential flood insurance would be required for government-backed mortgages. Since these properties are not mandated to have flood insurance, they may risk uncovered flood-related financial losses if the areas were to be inundated by a major flood event. In coastal areas, the corresponding share is much smaller, with slightly more than one-quarter of properties with at least a 1 percent annual chance of flooding by the FSF's modeling not being captured by the FEMA SFHA measure.

Those properties identified by the FSF as high exposure but not within FEMA SFHAs are more concentrated in LMI neighborhoods in both coastal and noncoastal areas, and in majority-POC neighborhoods in coastal areas. Since these properties fall outside of SFHAs, and thus are not required to purchase flood insurance, those FSF-designated properties are less likely to be insured, although they may be exposed to significant flood hazards, according to the FSF models.

At the same time, the FSF flood models may overlook certain parcels, primarily in coastal areas, that are a part of SFHAs. Properties that are inside SFHAs but are not FSF-designated are more prevalent in MUI tracts and majority-White tracts in both coastal and noncoastal areas. Owners of properties that are inside FEMA SFHAs but that are not considered high-hazard by the FSF measure may consider appealing FEMA's designation, depending on the property's risk profile.

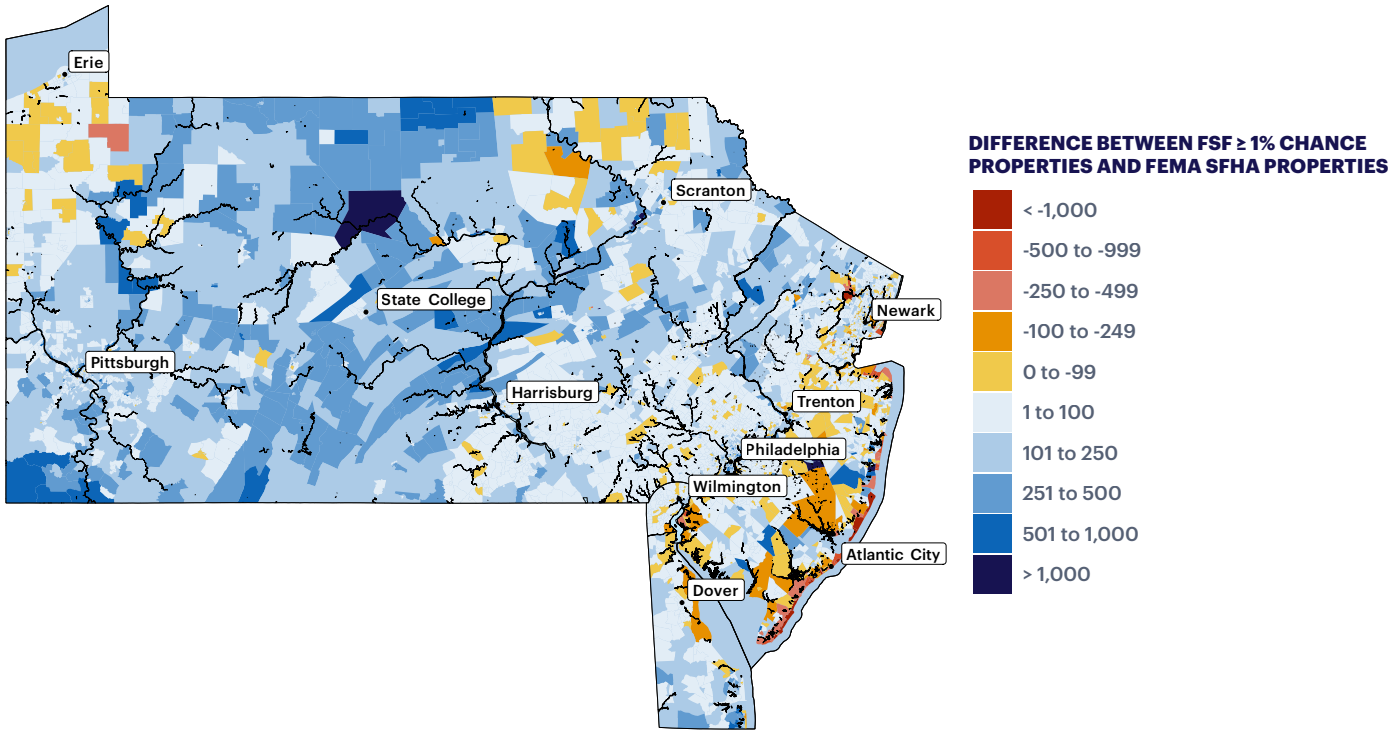
A nuanced geographic portrait of properties facing substantial flood exposure can be gained by mapping the difference in the number of such properties identified by the FEMA and FSF measures (Figure 3). Figure 3 shows that the FEMA SFHA measure identifies more

FIGURE 2 **Properties in Coastal/Noncoastal Areas in Third District States Within FEMA SFHAs and/or having FSF 1 Percent Annual Probability of Flooding by Tract Income Status, and Majority Race/Ethnicity**



Sources
Authors' calculation based on Climate Data via First Street Foundation and the 2022 FFIEC Census Flat File.

FIGURE 3 Difference in the Number of Properties Having FSF >=1 Percent Chance of Flooding and within FEMA SFHAs, Third District States



Notes
Tracts with blue shading indicate a greater number of FSF >=1 percent chance properties, tracts with red, orange, or yellow shading generally indicate greater number of FEMA-identified properties. Source: Authors' calculation based on Climate Data via First Street Foundation.

properties facing flood hazards in many coastal areas near the Atlantic Ocean, in a few scattered neighborhoods in northeast and northwest Pennsylvania, and in inland New Jersey (shaded in red or orange) than the FSF measure. The prevalence of blue shading in noncoastal areas in the Third District states, like in north and central Pennsylvania, indicate that the FSF measure identifies more properties than the FEMA SFHA measure in these areas.

Flooding Sources and Potential Losses from Flooding

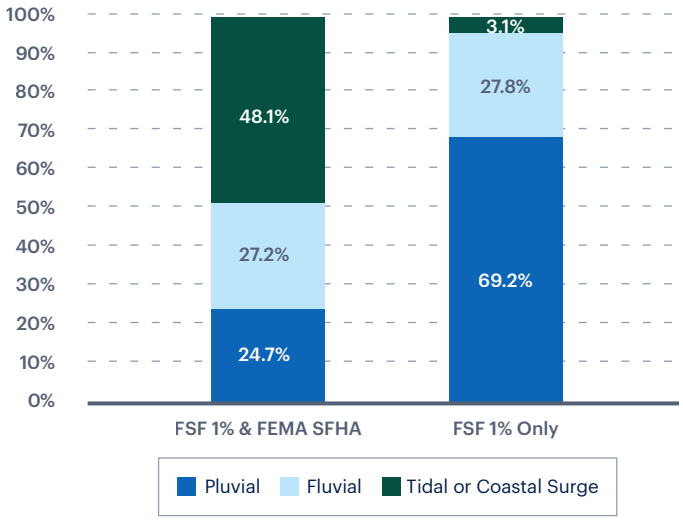
There are significant differences in the coverage and methodology of the FEMA and FSF flood hazard measures. FEMA's exclusion of pluvial flooding should help partially explain the observed incongruence. The FSF climate data provide information on the sources of flooding, either pluvial, fluvial, or tidal/coastal surge, for individual properties facing flood hazards. The results summarized in Figure 4 confirm the FEMA SFHA measure is less likely to cover pluvial flooding than the FSF measure. Pluvial flooding is the primary source of flooding for most of the FSF-rated only properties (69.2 percent) in Third District states. In contrast, pluvial flooding is considered as the flood source for only 24.6 percent of properties facing hazards agreed upon by both measures. Properties that have a higher flood exposure from tidal/coastal surge in the coastal areas tend to have more SFHA coverage, and few (3.1 percent) properties with significant tidal or coastal flooding exposure are captured only by the FSF measure. In other words, the FSF measure captures more properties exposed to pluvial flooding, while both measures are more likely to agree in their designation in areas facing either tidal/coastal surge or fluvial flooding exposure where the chance of flooding is greater.

There are some significant differences in the potential financial losses for properties identified by either or both measures of flood hazards. The FSF developed an average annual loss measure, which represents estimated repair costs associated with the expected flood damage. Using this measure shows that properties designated by both the FSF and SFHA measures are expected to bear higher average annual losses ($17,892) than those captured by the FSF measure alone ($7,745). There are at least two potential explanations for the differences in the estimated losses for properties identified by different measures. First, properties facing higher flooding exposure and larger losses from flooding are more likely to be captured by both the SFHA and FSF measures. Second, pluvial flooding (which is better captured by the FSF measure) likely causes less property damage compared with fluvial or tidal flooding events. The estimated average annual losses for high-hazard properties with different sources of flooding are consistent with these two notions: The average annual loss for properties

highly exposed to flooding according to both the SFHA and FSF measures would be $21,530 for those primarily exposed to fluvial flood sources, $11,004 for those primarily exposed to pluvial flood sources, and $19,065 for those primarily exposed to tidal flood sources. These values are much higher than for properties identified only by the FSF measure ($12,507, $5,905, and $5,362 for fluvial, pluvial, and tidal flooding, respectively). In other words, both measures are more likely to agree on properties with a higher exposure to flooding, like those caused by coastal and fluvial flooding, and those tidal/coastal and fluvial flooding events are likely to cause larger losses than pluvial flooding events.

In sum, both the FEMA and FSF measures have more alignment on flood risk in coastal communities, which have higher flood exposures on average. There are larger differences in noncoastal flood exposures, especially in LMI neighborhoods or in neighborhoods facing higher pluvial flood exposure. FEMA's SFHA measure tends to indicate that coastal, higher-income, and majority-White neighborhoods face greater exposure to floods. But the FSF's 1 percent probability measure further suggests that more noncoastal and LMI neighborhoods face greater exposure than the FEMA measure. The stock of flood-exposed properties identified by FEMA's SFHA tend to be overrepresented in MUI and majority-White communities in coastal areas, while the stock identified by the FSF measure tend to be overrepresented in noncoastal and LMI communities. Properties identified only by the FSF, however, primarily bear dangers from pluvial flooding that likely lead to less damage on average.

FIGURE 4 **Flood Sources of Properties in Areas Having at Least 1 Percent Annual Flooding Probability Identified by FEMA SFHA and FSF or by FSF Only, Third District States**



Sources
Authors' calculation based on Climate Data via First Street Foundation

Implications

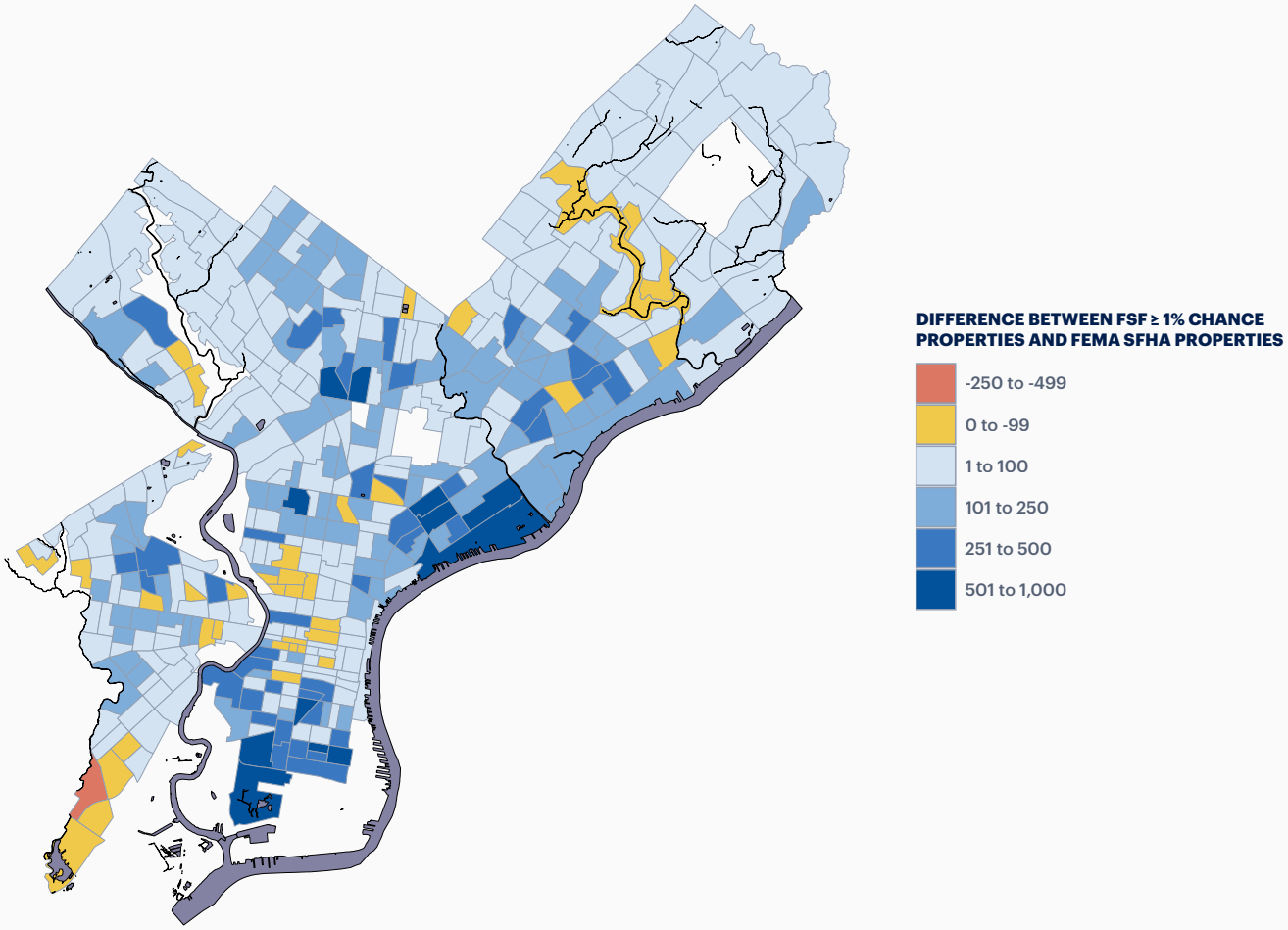
The traditional measure of assessing exposure to flooding — whether a property is located within a FEMA-designated flood zone — versus a newly introduced measure by the FSF provide quite different assessments of the scale and geography of flood danger across the Third District states. Coastal communities, which have higher flood exposures in general, tend to have higher SFHA coverage and more alignment with exposure determined by both the FEMA and FSF measures. But there are significant and systemic inconsistencies in assessments of non-coastal flood exposure. The FEMA measure indicates a larger number of properties in hazardous contexts in coastal areas, but the FSF measure does so in noncoastal areas.

When considering only properties where both FEMA and FSF measures agree that flood hazards are substantial, the pattern is that they are overrepresented in MUI and majority-White census tracts, especially in coastal areas. This pattern is likely explained by the fact that exposure to floods, unlike other hazards, is often accompanied by the compensating amenity of proximity to a body of water, which is often only affordable to higher-income households. The exclusion of pluvial flooding and the more limited coverage of FEMA SFHAs in noncoastal areas should help explain the results, but a more detailed analysis at smaller spatial scales, however, would be needed to determine the cause of the discrepancy with confidence.

Findings of this brief raise the question of whether the requirements for flood insurance for properties in a FEMA SFHA are sufficient to mitigate risk to properties in certain communities. There is a possibility that the traditional measure of flood danger based on FEMA flood zones underestimates current and future flood hazards to properties in certain communities, such as in many LMI neighborhoods in noncoastal areas. Since properties in these potential FEMA "blind spots" are not required to carry flood insurance, the implication is that GSEs and private mortgage lenders — as well as individual property owners — may bear risk they are unaware of, and that is likely underestimated, potentially leaving thousands unprepared for disasters. As a result, a concentration of high-hazard properties in coastal higher-income areas that are better covered by federal flood insurance and the challenge of high-hazard properties in noncoastal, lower-income areas that are likely underinsured coexist. Of course, the FSF exposure measure may or may not be the best measure of the flood hazard of a community, and how to make flood insurance more accessible and equitable is complicated by numerous social, political, and economic factors beyond the scope of this brief. Findings from this brief, however, should help shed light on the vulnerability of less advantaged communities in the Third District to the costliest natural disaster and the development of disaster resilience and mitigation programs for these communities.

CASE STUDY: PHILADELPHIA

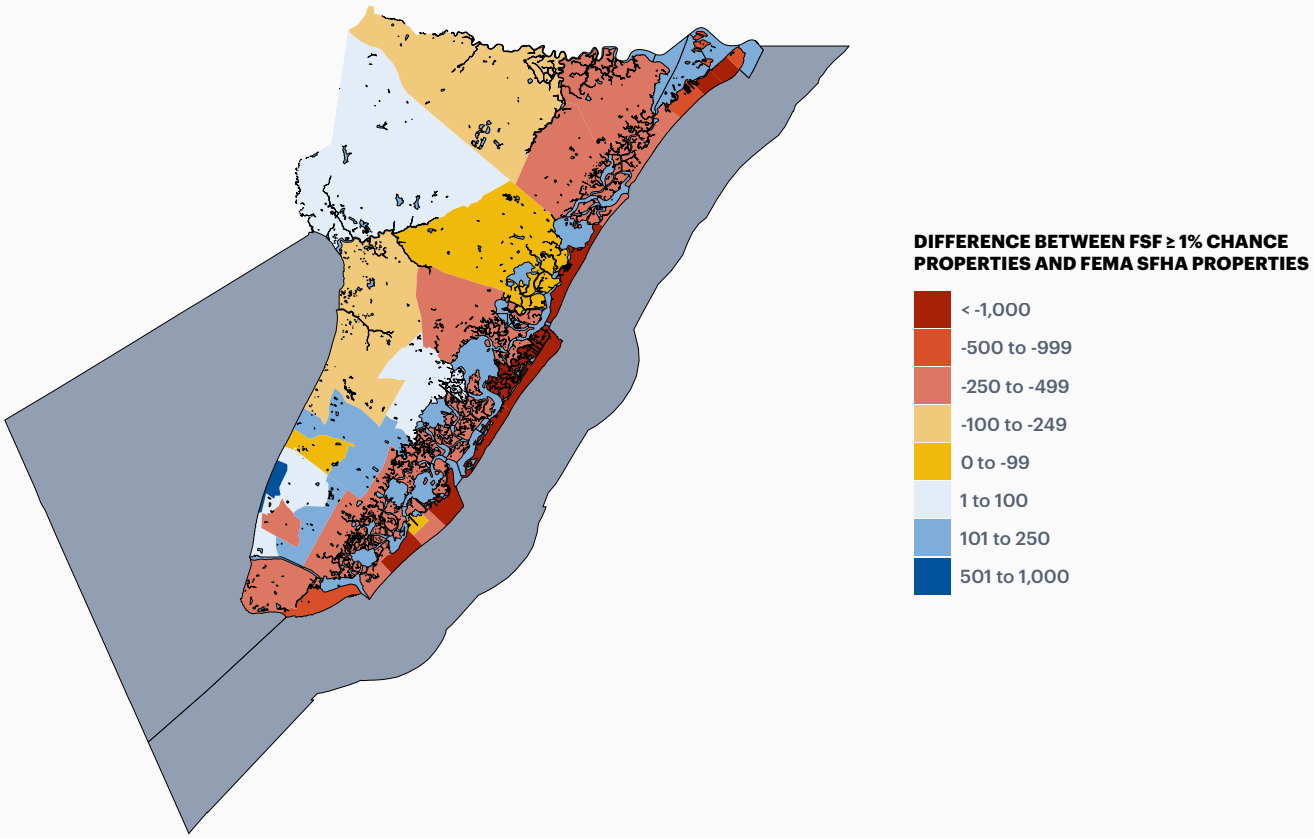
According to the FSF, about 8.4 percent of properties in the city have an annual chance of flooding of at least 1 percent, while 0.5 percent of properties are within FEMA SFHAs. In Philadelphia, FEMA SFHAs are primarily located near the Delaware and Schuylkill rivers, whereas the FSF identifies a greater number of properties with high exposure inland. The absolute differences between properties flagged as high exposure by the FSF and those in FEMA SFHAs are greatest in South Philadelphia, neighborhoods along the Delaware River, and select neighborhoods in North Philadelphia. There are only six neighborhoods where FEMA SFHA-designated properties outnumber FSF-identified ones. About 8.4 percent of properties in LMI neighborhoods are highly exposed to flooding, compared with 8.6 percent of properties in MUI neighborhoods, based on the FSF estimates.



Notes
Tracts with blue shading indicate a greater number of FSF >=1 percent chance properties, tracts with red, orange, or yellow shading generally indicate greater number of FEMA-identified properties. Source: Authors' calculation based on Climate Data via First Street Foundation

CASE STUDY: OCEAN CITY, NJ MSA

In the coastal MSA of Ocean City, NJ, the FSF estimates that 44.3 percent of properties in the metro area have an annual chance of flooding greater than 1 percent, while 58.1 percent of properties are within FEMA SFHAs. Neighborhoods along the coast have the largest shares of high-exposure properties, according to both the FSF 1 percent measure and FEMA SFHAs; however, FEMA SFHAs capture more properties directly on the coast. Both measures suggest that there is a greater share of properties with high exposure to flooding in MUI neighborhoods than in LMI neighborhoods. About 60 percent of properties in MUI neighborhoods are in FEMA SFHAs, versus 39.0 percent of properties in LMI neighborhoods. This compares with the FSF, which estimates that 44.6 percent of properties in MUI communities have an annual chance of flooding of at least 1 percent, versus 40.4 percent of properties in LMI neighborhoods.



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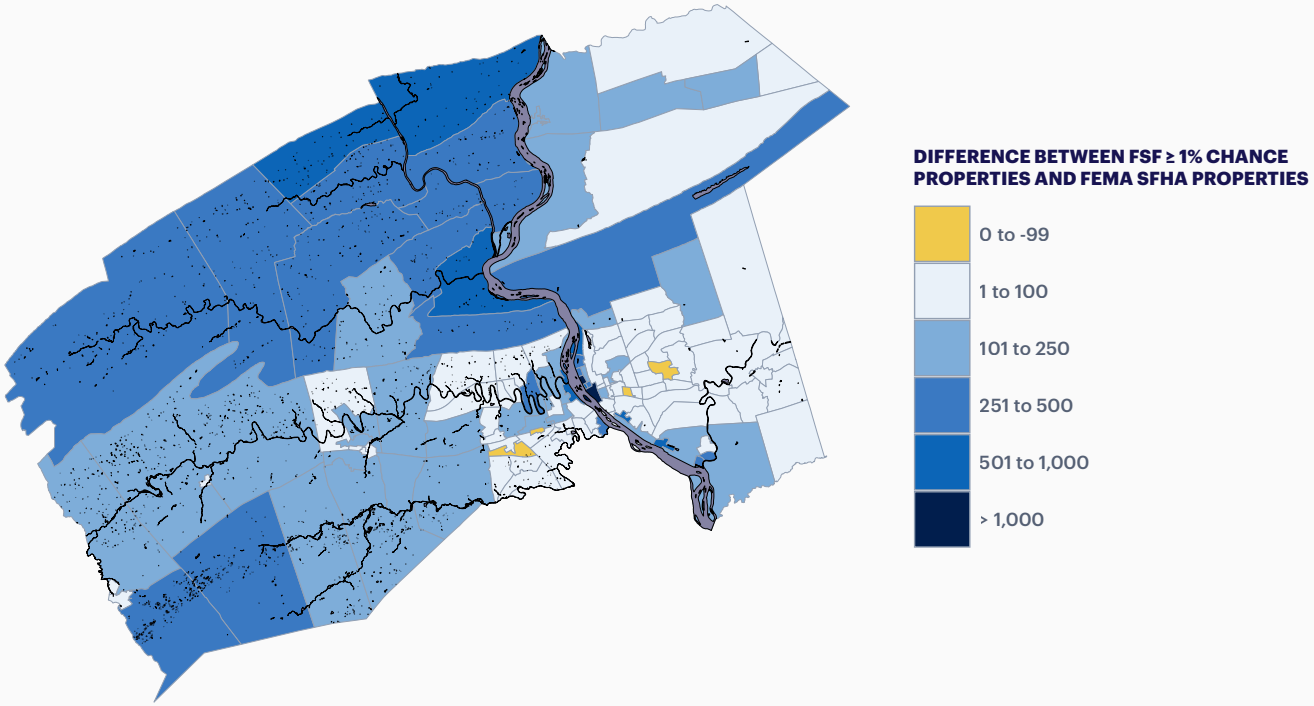
CASE STUDY: HARRISBURG-CARLISLE, PA MSA

The FSF estimates that 14.0 percent of properties in the Harrisburg-Carlisle, PA MSA have an annual chance of flooding greater than 1 percent. Both the FSF and FEMA identify that neighborhoods adjacent to the Susquehanna River have greater shares of properties with high exposure to flooding, although the FSF identifies more properties with high exposure than FEMA in most neighborhoods. The share of properties with high exposure identified by the FSF measure is nearly 10 percentage points higher than the share of properties in FEMA SFHAs (14.0 percent versus 4.4 percent). While the FSF estimates that 19.2 percent of properties in LMI neighborhoods have an annual chance of flooding that is at least 1 percent, only 5.2 percent of properties in LMI neighborhoods are within FEMA SFHAs. For both the FSF and FEMA SFHA measures, the shares of high-exposure properties are larger in LMI tracts than those in MUI neighborhoods, suggesting that LMI neighborhoods bear higher exposure than MUI neighborhoods in the Harrisburg-Carlisle MSA.



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Appendix

TABLE A1 Properties in the Third District within FEMA SFHAs or with FSF 1 Percent Annual Probability of Flooding, by State, Coastal/Noncoastal Areas, Income Status, and Majority Race/Ethnicity

	Third District States			Pennsylvania		New Jersey		Delaware	
	Total	Noncoastal	Coastal	Noncoastal	Coastal	Noncoastal	Coastal	Noncoastal	Coastal
Total properties	9,558,955	8,403,031	1,155,924	5,578,108	134,034	2,561,853	862,071	263,070	159,819
FEMA SFHA measure									
Total properties in FEMA SFHAs	639,583	324,602	314,981	213,333	6,749	106,161	282,882	5,108	25,350
% of properties in FEMA SFHAs	6.7%	3.9%	27.3%	3.8%	5.0%	4.1%	32.8%	1.9%	15.9%
By tract income									
Low- and moderate-income	5.6%	3.5%	19.7%	3.4%	4.7%	4.0%	25.4%	1.8%	12.6%
Middle- and upper-income	7.0%	4.0%	29.6%	4.0%	5.4%	4.2%	34.8%	2.0%	16.7%
By tract majority race/ethnicity									
Majority People of Color	4.3%	2.3%	16.5%	1.0%	4.7%	3.7%	21.9%	1.3%	6.4%
Majority Non-Hispanic White	7.2%	4.2%	30.1%	4.2%	5.2%	4.4%	35.4%	2.2%	17.8%
FSF 1 percent measure									
Total properties identified by FSF	1,099,532	802,983	296,549	609,127	13,658	180,450	249,612	13,406	33,279
% of properties identified by FSF	11.5%	9.6%	25.7%	10.9%	10.2%	7.0%	29.0%	5.1%	20.8%
By tract income									
Low- and moderate-income	12.7%	11.4%	21.8%	12.8%	10.2%	8.8%	26.2%	4.7%	17.1%
Middle- and upper-income	11.1%	9.0%	26.8%	10.3%	10.1%	6.6%	29.7%	5.2%	21.7%
By tract majority race/ethnicity									
Majority People of Color	9.1%	8.0%	16.0%	8.8%	7.4%	7.6%	19.4%	3.1%	11.7%
Majority Non-Hispanic White	12.1%	9.9%	28.2%	11.2%	11.9%	6.8%	31.2%	5.8%	22.7%

Sources
Authors' calculation based on Climate Data via First Street Foundation and the 2022 FFIEC Census Flat File.

Appendix

TABLE A2 Share of High-Hazard Properties by FEMA SFHA and FSF Measures for Third District MSAs

MSA	Total prop.	Properties within FEMA SFHAs			Properties identified by FSF 1 percent measure		
		Share of prop. in SFHAs	Share of prop. in LMI neighborhoods in SFHAs	Share of prop. in MUI neighborhoods in SFHAs	Share of prop. with 1% or higher chance of flooding	Share of prop. in LMI neighborhoods with 1% or higher chance of flooding	Share of prop. in MUI neighborhoods with 1% or higher chance of flooding
Allentown-Bethlehem-Easton, PA-NJ MSA	333,831	2.7%	2.5%	2.8%	7.8%	7.9%	7.7%
Altoona, PA MSA	63,801	7.2%	4.3%	7.9%	17.8%	15.1%	18.5%
Atlantic City-Hammonton, NJ MSA	156,902	25.8%	53.5%	20.7%	21.9%	43.3%	17.9%
Bloomsburg-Berwick, PA MSA	41,179	7.8%	3.3%	8.2%	22.2%	13.9%	22.9%
Chambersburg-Waynesboro, PA MSA	71,282	2.1%	1.4%	2.2%	10.6%	9.0%	10.7%
Dover, DE MSA	81,192	4.0%	12.1%	2.2%	6.6%	13.3%	5.1%
East Stroudsburg, PA MSA	98,474	2.4%	1.6%	2.4%	8.3%	6.4%	8.5%
Gettysburg, PA MSA	43,539	3.3%	5.4%	2.7%	6.8%	9.5%	6.2%
Harrisburg-Carlisle, PA MSA	226,292	4.4%	5.2%	4.1%	14.0%	19.2%	12.8%
Johnstown, PA MSA	84,219	6.5%	16.7%	4.8%	15.0%	32.6%	12.2%
Lancaster, PA MSA	184,283	1.6%	1.1%	1.7%	5.7%	8.4%	5.2%
Lebanon, PA MSA	52,495	2.1%	1.4%	2.3%	6.4%	10.0%	5.6%
Ocean City, NJ MSA	146,797	58.1%	39.0%	59.6%	44.3%	40.4%	44.6%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA	2,247,203	2.8%	3.3%	2.6%	6.7%	9.0%	5.8%
Reading, PA MSA	155,641	2.3%	0.7%	2.7%	8.2%	9.7%	7.9%
Scranton–Wilkes-Barre–Hazleton, PA MSA	285,220	5.6%	4.4%	6.0%	16.4%	16.3%	16.4%
State College, PA MSA	58,054	5.0%	7.6%	4.4%	13.5%	16.6%	12.5%
Trenton, NJ MSA	139,823	3.3%	3.8%	3.0%	7.8%	13.1%	4.4%
Vineland-Bridgeton, NJ MSA	73,380	7.4%	5.8%	7.8%	10.8%	9.0%	11.3%
Williamsport, PA MSA	51,037	11.0%	0.0%	11.8%	27.1%	62.3%	24.2%
York-Hanover, PA MSA	171,823	2.3%	1.0%	2.5%	7.0%	7.8%	6.8%
Non-MSA	971,220	8.2%	10.1%	8.0%	16.5%	24.2%	15.6%
Non-Third District MSA	3,821,268	7.4%	5.8%	7.9%	11.7%	12.8%	11.3%
Total	9,558,955	6.7%	5.6%	7.0%	11.5%	12.7%	11.1%

Sources
Authors' calculation based on Climate Data via First Street Foundation and the 2022 FFIEC Census Flat File.

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