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UNDERSTANDING FLOOD SCENARIOS: A ROADMAP TO RESILIENCE HOMESTEAD, FL

PROJECT REPORT 2025-004

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Understanding Flood Scenarios: A Roadmap to Resilience for Homestead, FL

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This report was prepared by the Project IN-CORE Team as part of the Geos Institute's Climate Ready America Southeast Navigator Network with funding from the Walmart Foundation to analyze future flood hazard scenarios and implement risk reduction and resilience planning strategies.

February 2025

Credits and Acknowledgements

Project IN-CORE Team

Project IN-CORE is a fiscally sponsored project of Community Initiatives, a non-profit dedicated to helping communities thrive. Project IN-CORE's objective is to apply IN-CORE capabilities to provide technical assistance and scenario-based modeling to develop resilience strategies for future flood hazards.

Project IN-CORE Homestead Report Authorship

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Geos Institute's Navigator

The Geos Institute's Navigator program supports communities in building climate resilience by providing access to funding, capacity-building resources, and technical assistance. Through its Southeast Navigator Network, the program fosters collaboration across Florida, South Carolina, North Carolina, and Georgia, focusing on Community Disaster Resilience Zones.

A special thank you to *Navigator* Alicia Bradigan-Betancourt of UF IFAS Monroe County Extension Director

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The mapped flood depths used in these analyses have been developed from climate projections generated by Argonne National Laboratories in collaboration with the AT&T Foundation and provided to Project IN-CORE by the AT&T Foundation for the development of use cases of the climate data available on the Climate Risk and Resilience Portal (ClimRR). A version of this data will be available on the ClimRR portal.

Funding Acknowledgements

This report was prepared by the Project IN-CORE Team as part of the Geos Institute's Climate Ready America Southeast Navigator Network with funding from the Walmart Foundation to analyze future flood hazard scenarios and implement risk reduction and resilience planning strategies. The findings, conclusions, and recommendations presented in this report are those of the authors alone and do not necessarily reflect the opinions of the Walmart Foundation.

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1. Purpose and Objective

This study provides a comprehensive flood resilience analysis for Homestead, assessing vulnerabilities to future flooding. It evaluates hazard scenarios to identify areas at risk from current and mid-century flooding, considering precipitation's increasing frequency and intensity. By highlighting evolving risks, the study equips policymakers and stakeholders with data-driven insights to inform resilience planning, support urban growth, and enhance flood mitigation efforts. The overarching goal is strengthening the county's capacity to navigate flood risk uncertainties while leveraging data for informed decision-making and grant opportunities.

The analysis was conducted using the IN-CORE platform (www.in-core.org), incorporating its Flood Damage Analysis and Population Dislocation Models. To account for mid-century climate conditions, flood data from the Climate Risk and Resilience Portal (ClimRR) was integrated, providing a comprehensive assessment of climate projections and future risks.

2. Background

Homestead, Florida, is a growing city in Miami-Dade County, located between the Everglades and Biscayne Bay (Figure 1). With a population of approximately 80,000 (Census, 2023), it serves as a key residential and economic hub in South Florida. Historically rooted in agriculture, Homestead has evolved into a diverse community with expanding residential, commercial, and industrial developments. Its strategic location along major transportation corridors, including U.S. Route 1 and Florida's Turnpike, connects it to the greater Miami metropolitan area.

Despite its economic growth, Homestead faces significant climate-related challenges, particularly from hurricanes, storm surges, and flooding. Its low-lying geography and proximity to coastal and wetland areas make it highly susceptible to extreme weather events, which have intensified in frequency and impact. In recent years, the city has experienced several federally declared disasters, highlighting the urgency of proactive resilience planning. As Homestead grows, balancing development with climate adaptation remains critical for ensuring long-term sustainability and community resilience.

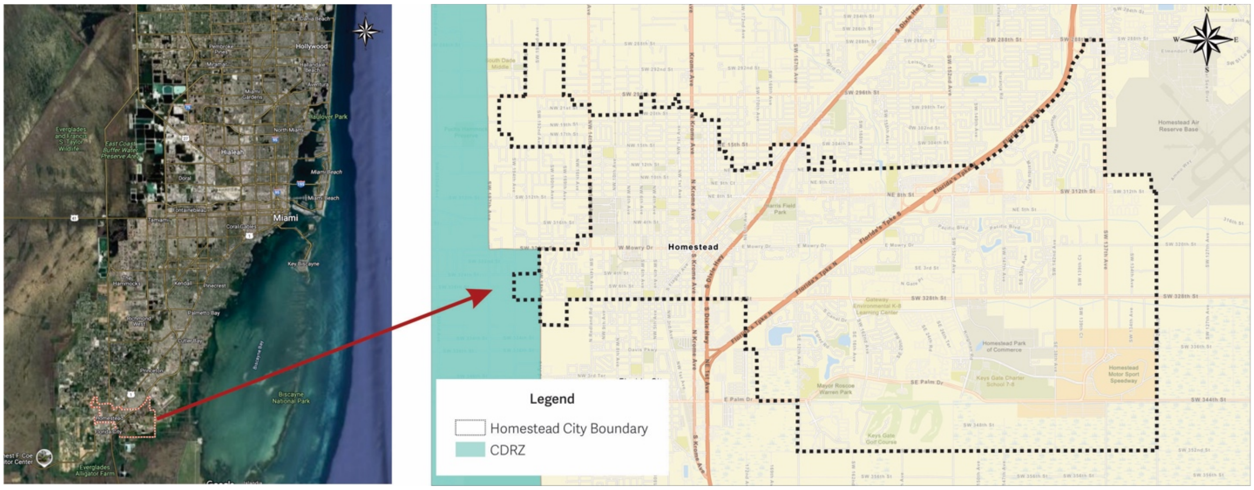

Figure 1. Homestead, Florida

3. Future Flood Hazard Scenarios and Impacts

This section was developed using the Interdependent Networked Community Resilience Modeling Environment (IN-CORE) and ClimRR flood hazard data. IN-CORE is a powerful computational tool designed to help communities model natural hazards, assess risks, and develop strategies to enhance resilience and recovery. ClimRR (Climate Risk and Resilience Portal) is an online platform that provides detailed climate data and future flood projections to help communities prepare for climate-related risks. It was developed by Argonne National Laboratories and shared by Project IN-CORE's collaboration with the AT&T Foundation.

To run IN-CORE, we used building data inventory from the National Structures Inventory (NSI). The details of the methodology are provided in Appendix A. The flood scenarios in this report are based on mid-century climate projections (2045–2054) from ClimRR. These scenarios include a 100-year coastal flood, which accounts for rising sea levels and storm surges from hurricanes and tropical storms, and a 50-year inland flooding event caused by heavy rainfall (pluvial flood). This approach helps capture the increasing intensity of future storms and rainfall patterns.

The information in the current report is useful for understanding potential future flooding conditions. However, they do not include river flooding or municipal stormwater systems information. For river flooding, FEMA flood maps are still a reliable source. For urban flooding, a more detailed analysis of stormwater systems may be needed. The results presented should be interpreted considering these limitations.

3.1. Flood Hazard Zones

Flood hazard zones are designated areas that reflect varying levels of flood risk, helping communities plan for and mitigate potential flood impacts. These zones are established by FEMA through Flood Insurance Rate Maps (FIRM), which assess flood probability based on historical data, topography, and hydrological modeling. Figure 2 shows the areas in Homestead that fall within the FEMA-established Hazard Zones.

- **AH zone:** Areas subject to shallow flooding, with average depths ranging from 1 to 3 feet. These areas are usually characterized by defined Base Flood Elevations (BFE), which indicate the anticipated water level during a 1% annual chance flood (also known as a 100-year flood). Properties within AH zones are at risk of moderate flooding, and FEMA requires flood insurance for structures in these zones with federally backed mortgages.
- **Zone X shaded:** This area has a 0.2% annual chance of flooding or a 1-in-500-year chance of experiencing a flood event in any given year. While considered a moderate flood risk, flooding can still occur, particularly during extreme weather. Properties in this zone are not required to have flood insurance under the National Flood Insurance Program (NFIP), but they remain vulnerable to significant flooding.

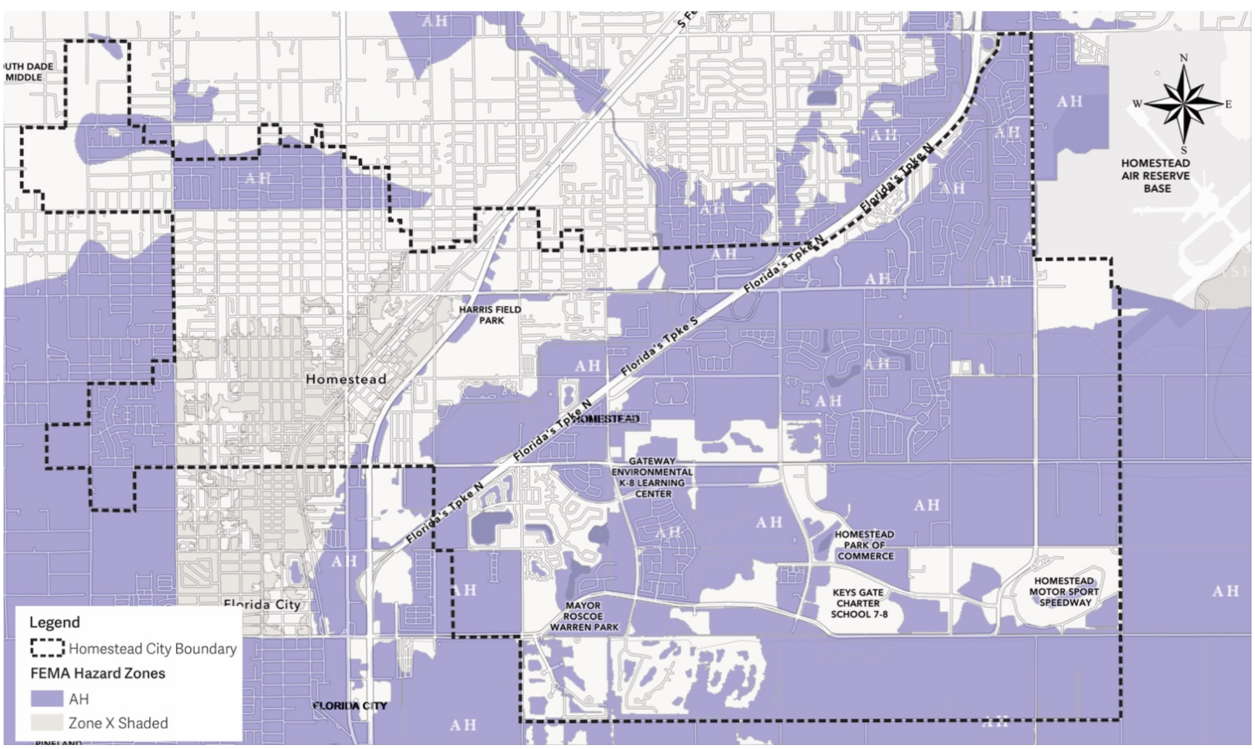

Figure 2. FEMA-established Hazard Zones in Homestead, FL

3.2. Flood Damage Analysis

The building damage analysis estimates damage levels by considering building categories and simulated flood scenarios across the region, as detailed in the methodology in Appendix A. In this analysis, the term Damage State (DS) is used to represent different levels of damage, which are explained below:

- **DS 0 (No Damage or Slight Damage)**: The building experiences no visible damage from flooding. All structural and non-structural elements remain intact, with no repair required. It can have minor impacts from flooding, such as superficial water staining, damp walls, or minimal seepage into basements or ground floors. Repairs are light and typically involve cleaning or cosmetic fixes.
- **DS 1 (Moderate Damage):** Floodwaters cause more significant damage, such as partial inundation of ground floors, damage to finishes like flooring and drywall, and minor effects on electrical or plumbing systems. Repairs are required, but the structural integrity remains intact.
- **DS 2 (Severe Damage):** Substantial flooding leads to significant structural impacts, such as prolonged submersion of key components, damage to load-bearing walls, or failure of essential systems (e.g., electrical, HVAC). The building may be uninhabitable until extensive repairs are completed.
- **DS 3 (Complete Damage):** The building is fully inundated or structurally compromised, resulting in total loss. Repairs are not feasible, and the structure may need to be demolished and rebuilt.

Table 1 summarizes the results of the building damage analysis. The results highlight only buildings with a probability greater than 50% of being damaged within each category. The flood depths used in our modeling represent realistic events that the local community is likely to encounter and should be prepared to repeatedly withstand in the coming years rather than a worst-case scenario. Appendix A provides more details on the methodology. Low-level damage (Damage State 1) is expected for approximately 49.14% of buildings, and 120 buildings are likely to experience moderate to severe damage (Damage States 2).

Table 1: Summary of the building damage analysis – Homestead

Damage State	Building Count	% of Buildings
Damage State 0 (No Damage or Slight Damage)	12564	50.38%
Damage State 1(Moderate Damage)	12256	49.14%
Damage State 2 (Severe Damage)	101	0.40%
Damage State 3(Complete Damage)	19	0.08%

Source: IN-CORE
*The results highlight only buildings with a probability greater than 50% of being damaged within each category.

Figure 3 highlights priority areas where buildings face a significant risk of severe (DS2) or complete damage (DS3). While most of these areas are within Flood Hazard Zone AH (Figure 2), the actual flood impact appears to be far more severe than predicted by the zone. FEMA estimates that Zone AH is subject to moderate flood damage, with water depths ranging from 1 to 3 feet. However, our model indicates that certain areas within this zone, for example, those near the Florida Turnpike (Highway 821), may experience flood depths between 3 to 10 feet. Therefore, high-risk areas should be prioritized for mitigation efforts, including stricter building regulations, new construction elevation requirements, and flood-resistant design measures to enhance resilience.

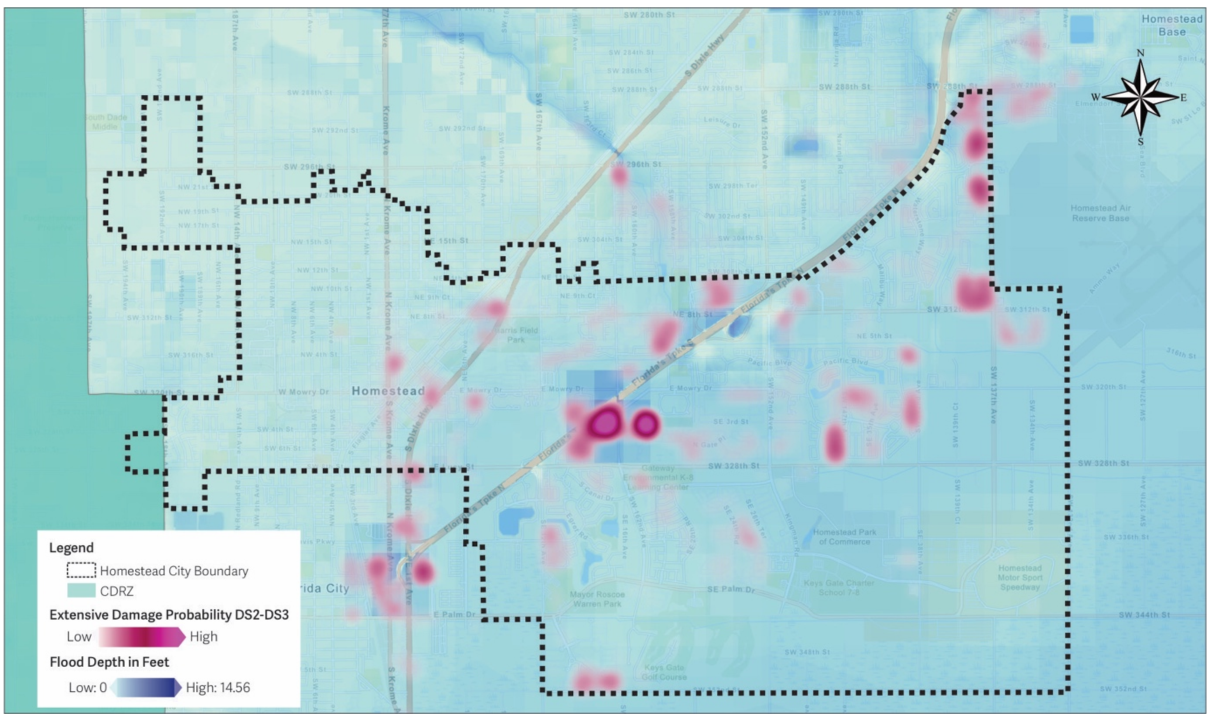

Figure 3. Areas with the probability of experiencing severe (DS2) and complete damage (DS3)

Aside from these concentrated pockets with a probability of severe (DS2) and complete damage (DS3), almost all the buildings in Homestead are projected to see some degree of damage (Figure 4) due to its very low elevation. About 49% of the buildings have a probability greater than 50% of being impacted by moderate damage (DS1), and most of them are located on the east side of S Homestead Blvd. and east of Florida's Turnpike, where some areas are already defined as Flood Hazard Zone AH (Figure 2). However, moderate flood damage is not limited to Zone AH, as several areas outside the designated flood hazard zones also show susceptibility to moderate flooding, with water depths ranging from 1 to 3 feet, highlighting the need for broader mitigation efforts beyond officially mapped risk zones.

While a single occurrence may not pose a significant threat, global climate models suggest that the flooding events outlined in this report are likely to become more frequent as the century progresses. As a result, repeated flood events could increasingly impact these areas, raising concerns about structures currently classified as DS1. Ongoing exposure may gradually weaken their functionality and structural integrity, ultimately affecting a larger portion of the building stock.

In these areas, proactive flood management strategies are essential to mitigate moderate flood damage. Key measures include avoiding utility installations in flood-prone crawl spaces, installing sump pumps in areas prone to recurrent low-level flooding, and implementing strategic landscaping to direct heavy rainfall away from building foundations. Additionally, nature-based solutions, such as enhancing soil infiltration, expanding green infrastructure, and preventing erosion in low-lying areas, play a critical role in reducing flood impacts and strengthening long-term resilience.

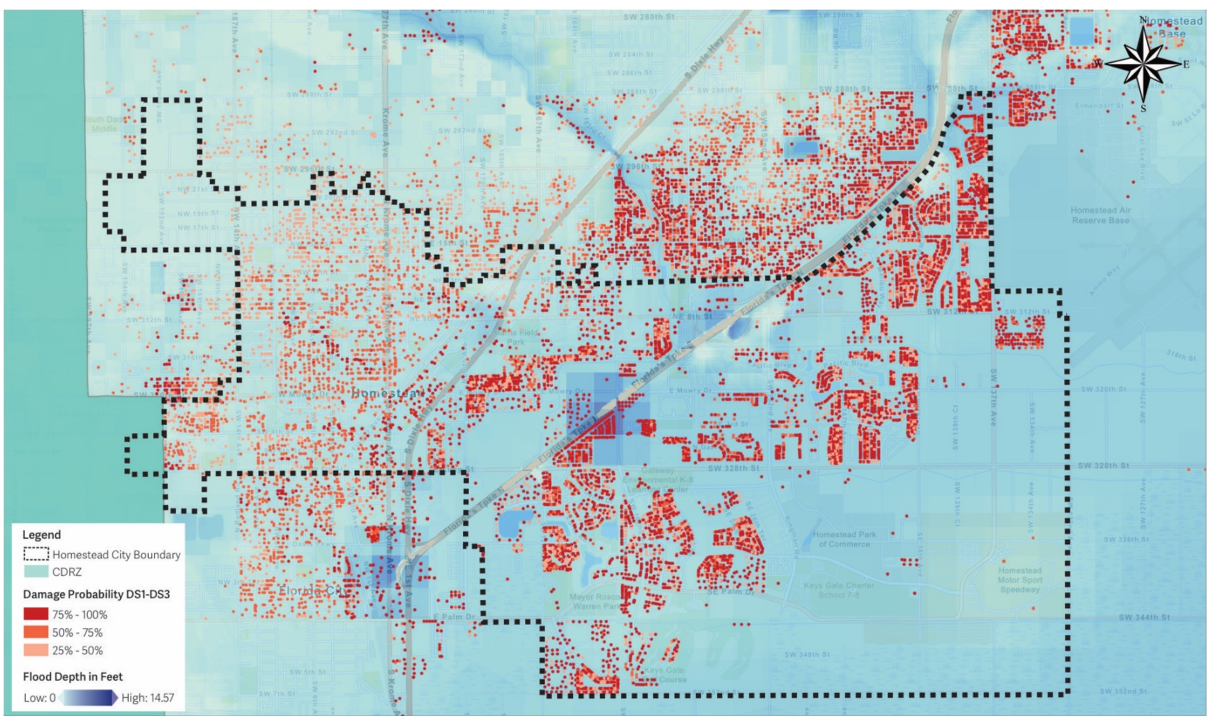

Figure 4. Areas with the probability of experiencing Damage State 1 (moderate flood damage)

3.3. Population Dislocation

Population dislocation refers to the displacement or temporary relocation of individuals due to disasters (Oliver-Smith, 2018). While people are the cornerstone of community resilience planning, existing models prioritize buildings and infrastructure over human-centered considerations. This repository addresses this gap by integrating people into community resilience models and linking population dynamics with building data.

The dislocation model relies on data about both people and structures. A specialized Python package, **Pyncoda**, developed under the Center of Excellence for Risk-Based Community Resilience Planning, is utilized to allocate population data to housing units (Rosenheim et al., 2021). This tool synthetically assigns households to housing units, enabling a more comprehensive understanding of community resilience. A detailed explanation of the methodology is provided in Appendix B. The synthetic population's demographic characteristics match the Census block group's characteristics. This work is described as follows by Pyncoda's README file on GitHub authored by Nathanael Rosenheim (2022).

Once a housing unit allocation has been generated, then the damage result for each building can be combined with the social data for each household, such as tenure status, race, and household income, to determine whether a household is likely to temporarily relocate due to a hazard event, in this case, flood. The results of a population dislocation analysis can be analyzed further to understand the equity impacts of such hazards. Figure 5 shows dislocated households in Homestead after a simulated hazard event. Details of this procedure can be found in the population dislocation methodology section (Appendix B). Minimizing damaged areas will also minimize population dislocation.

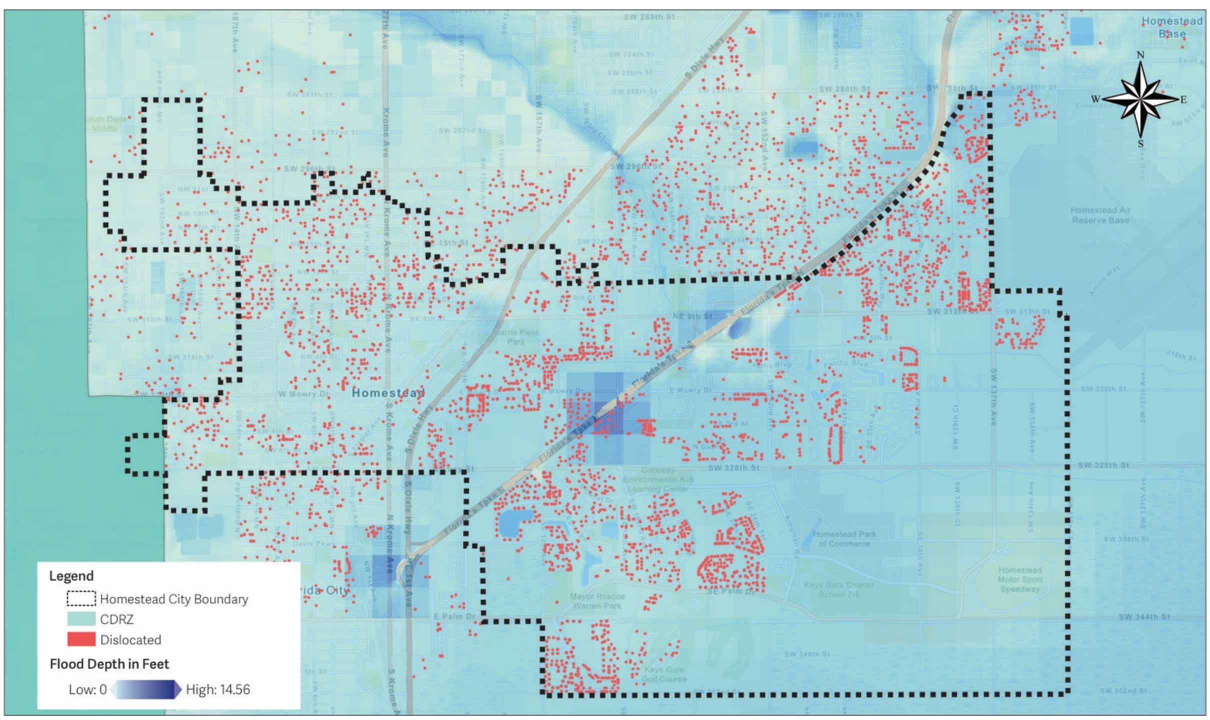

Figure 5. Population Dislocation

4. Current Planning Initiatives for Flood Resilience

Homestead is actively implementing flood resilience initiatives to mitigate its vulnerability to flooding and sea-level rise. One significant project is the hardening of Pump Station 22, which serves a 200-acre area with approximately 9,321 residents and numerous businesses. This $2.51 million infrastructure upgrade includes installing new pumping units and a force main to enhance the station's capacity and protect it from wind and flooding impacts, ensuring reliable wastewater management (FEMA, n.d.). In addition to infrastructure improvements, Homestead participates in the National Flood Insurance Program's Community Rating System (CRS), a voluntary program that incentivizes communities to adopt enhanced floodplain management practices. As of April 1, 2024, Homestead has achieved a Class 7 rating, providing a 15% discount on flood insurance premiums for properties in Special Flood Hazard Areas (FEMA, 2024). This section examines key policies, plans, and ordinances related to flood resilience, assessing the city's ongoing efforts, toward resilience.

Economic Development Workplan 2023

The Homestead Economic Development Workplan does not directly mention resilience or climate adaptation strategies, but several of its proposals can be integrated into a broader flood resilience framework. The plan focuses on economic growth, infrastructure investment, and quality of life improvements, emphasizing downtown revitalization, business attraction, and land-use planning. While it does not explicitly address flood mitigation or climate adaptation, its recommendations for redevelopment, regulatory enhancements, and infrastructure improvements present opportunities to incorporate resilience measures, such as improved drainage systems, elevation standards for new developments, and incentives for climate-resilient construction. Additionally, leveraging the city's natural assets, including its proximity to Everglades and Biscayne National Parks, could support eco-tourism and green infrastructure initiatives that enhance economic development and environmental sustainability.

Southwest Neighborhood Master Plan 2021

The Southwest Neighborhood Master Plan aims to guide the redevelopment of the Southwest Neighborhood through mixed-use, pedestrian-friendly, and context-sensitive urban planning strategies. The plan replaces conventional zoning with a form-based code, emphasizing the relationship between buildings and public spaces rather than rigid land-use separation. It promotes compact, walkable development, increased housing opportunities, and economic revitalization, particularly in historically underserved areas. Key elements include design standards for various building types, street typologies, and public spaces, ensuring compatibility with existing urban fabric while fostering long-term economic growth. The plan also integrates affordable housing policies, transit-oriented development principles, and public realm enhancements to create a thriving and inclusive neighborhood.

While the plan does not explicitly mention resilience or flood mitigation, the Southwest Neighborhood is likely to face moderate flood damage, and several of its proposals can be adapted to enhance flood resilience. The emphasis on walkability, mixed-use development, and green spaces provides opportunities to incorporate stormwater management strategies, such as permeable pavements, bioswales, and flood-resilient building designs. Additionally, the plan's focus on transit-oriented development and connectivity could support the integration of climate adaptation strategies, reducing car dependency and mitigating heat island effects. Strengthening the plan with climate-conscious policies—such as improved drainage infrastructure, elevation standards for new developments, and incentives for flood-resilient construction—would enhance the neighborhood's ability to withstand climate risks while maintaining its economic and social vitality.

Parks Master Plan 2022

The 2022 Homestead Parks and Recreation Master Plan aims to guide the future development and enhancement of parks, recreation facilities, and services in the City of Homestead. The plan focuses on improving accessibility, expanding recreational opportunities, and modernizing park infrastructure to meet the community's needs. Key objectives include maximizing the use of existing recreational spaces, ensuring equitable distribution of facilities, and fostering cross-generational engagement through diverse programming. The plan identifies specific parks and recreation improvements, such as upgrading playground equipment, expanding green spaces, and implementing landscaping strategies to enhance shade and usability. Additionally, it emphasizes community engagement in the planning process to ensure that investments align with residents' priorities.

While the plan does not explicitly address flood resilience or climate adaptation, several proposals can be integrated into a broader resilience framework. The focus on landscaping improvements, tree canopy expansion, and stormwater management in park designs presents an opportunity to enhance flood resilience. Incorporating permeable surfaces, bioswales, and improved drainage infrastructure within parks can help mitigate urban flooding while maintaining recreational functionality. By integrating climate-conscious design principles into park improvements, the city can create multi-functional public spaces that contribute to community well-being and long-term resilience.

CRA Redevelopment Plan 2020

The Homestead Community Redevelopment Agency (CRA) Annual Report 2020 outlines the agency's efforts to eliminate blight, support economic development, and improve public spaces within the designated redevelopment area. Established after Hurricane Andrew in 1994, the CRA focuses on revitalizing Historic Downtown Homestead and the Southwest Neighborhood, leveraging Tax Increment Financing (TIF) to fund projects. The report highlights initiatives such as property acquisitions, infrastructure improvements, small business support, and community engagement programs. Major developments include the Losner Park expansion and the Homestead Cybrarium, a high-tech library designed to enhance literacy and learning. Additionally, the CRA provided COVID-19 relief grants to assist small businesses and residents with rent and utility costs, demonstrating its role in both economic stabilization and long-term redevelopment planning.

Although the report does not explicitly address flood resilience or climate adaptation, several buildings within the CRA area are at risk of moderate flood damage, and many of its projects can be adapted to enhance resilience. The CRA's focus on redevelopment, infrastructure improvements, and public space enhancements presents an opportunity to incorporate stormwater management strategies, permeable surfaces, and green infrastructure into urban renewal efforts. Enhancing tree canopy coverage, integrating bioswales, and modernizing drainage systems within revitalization projects could mitigate flood risks while improving overall community resilience.

Comprehensive Plan 2011

The Homestead Comprehensive Plan is a guiding framework for the city's long-term growth and development, ensuring sustainable land use, economic expansion, infrastructure improvements, and quality-of-life enhancements. The plan provides a strategic approach to future land use, transportation, housing, public services, economic development, and environmental conservation, aligning with state and regional planning policies. It prioritizes redevelopment and infill development, particularly in the Historic Downtown District and Southwest Neighborhood, while supporting mixed-use, transit-oriented, and pedestrian-friendly urban designs. Additionally, the plan includes objectives for hurricane evacuation, hazard mitigation, and green building standards, aiming to enhance the city’s resilience to environmental and economic challenges. Several of its strategies can be integrated into a broader flood resilience framework, such as:

- **Drainage and Flood Protection Standards:** To mitigate flood risks, the City requires all developments to meet a minimum drainage level-of-service standard that provides protection from a one-day storm event occurring once every five years. Land designated for urban development must meet or exceed Miami-Dade County’s flood criteria, as established in Resolution R-951-82, ensuring that all structures are built at or above the Federal Flood Insurance Rate Maps (FIRM) elevations. Additionally, all water exiting City drainage systems must comply with federal, state, and county water quality standards to minimize environmental impacts.
- **Participation in the Community Rating System (CRS):** The City is committed to improving its standing in the CRS, which will help reduce flood insurance costs for residents while improving its preparedness and response to flood hazards.
- **Public Awareness and Hazard Mitigation Outreach:** Recognizing the importance of community engagement, the City continually disseminates information about flood risks and available mitigation measures. This includes

providing residents with updates on flood hazards and promoting sustainable land-use practices that reduce vulnerability to flooding.

- **Environmental Conservation and Resource Protection:** The Comprehensive Plan also includes measures to protect natural resources contributing to flood resilience. The City maintains a public education program that promotes conservation efforts related to floodplains, wetlands, soils, fisheries, and wildlife habitats. These natural areas play a critical role in absorbing floodwaters and reducing the severity of flood events.
- **Land Use and Development Regulations:** To enhance community aesthetics, property values, and flood resilience, the City regulates property improvements such as signage, fencing, subdivision standards, and landscaping. Regulations also address development in flood-prone areas, stormwater management, and ensuring safe and convenient on-site traffic flow and parking.
- **Land Development Code Enforcement:** The City's Land Development Code provides regulations for concurrency, signage, subdivisions, landscaping, environmental protection, and sound attenuation, ensuring that all development aligns with flood resilience goals. It also includes specific provisions for managing seasonal or periodic flooding, ensuring that future growth does not increase flood risks.

Although the city has established strategies for flood risk management, the key limitation is that these strategies are largely confined to areas identified in FEMA Flood Insurance Rate Maps. However, as demonstrated in section 3.2, additional areas outside these designated flood zones also exhibit flood vulnerability. To strengthen the city's resilience, flood mitigation measures should include all identified vulnerable areas, ensuring a more comprehensive and adaptive approach to flood risk management.

2024 Sea Level Rise and Flood Resilience Plan

The 2024 Sea Level Rise and Flood Resiliency Plan is a comprehensive strategy to address the increasing risks of flooding, sea level rise, and climate impacts on South Florida's water resources. Developed by the South Florida Water Management District (SFWMD), the plan outlines priority projects to upgrade flood control infrastructure, enhance water management systems, and improve community and ecosystem resilience. The goal is to strengthen flood protection across the Central & South Florida Flood Control System (C&SF) and the Big Cypress Basin by incorporating nature-based solutions, infrastructure adaptations, and scientific assessments. The plan also emphasizes a collaborative approach, working with local, state, and federal agencies to integrate the best available data and hydrologic modeling to guide decision-making.

Key findings indicate that existing flood control infrastructure faces vulnerabilities due to rising sea levels, changing rainfall patterns, and aging systems. The plan recommends enhancing canal banks, increasing storage capacity, hardening levees, improving discharge capacity, and incorporating a "self-preservation mode" in water control structures. Additionally, it highlights the need for multi-criteria assessments to prioritize projects based on vulnerability, cost-effectiveness, and resilience benefits. To enhance flood resilience in Homestead, the plan suggests expanding mitigation measures beyond FEMA-designated flood zones to areas identified as vulnerable through new assessments. The plan aims to strengthen regional resilience, reduce flood risks, and protect critical water resources in South Florida by integrating gray and green infrastructure and securing state and federal funding. Specific projects involving Homestead are:

- **Homestead Field Station Replacement:** The plan includes upgrades and replacements for the Homestead Field Station, which plays a key role in maintaining flood control structures in the area.
- **S-18C Structure Resiliency:** The S-18C spillway, located southeast of Homestead, regulates water levels in the C-111 Spreader Canal and prevents saltwater intrusion. Planned improvements include hydraulic upgrades to maintain optimal water control, enhance flood protection, and moderate freshwater discharges to Everglades National Park and Florida Bay.
- **L-31E Levee Improvements:** Retrofitting and raising the eastern canal bank elevation of the L-31E levee, a key component of Homestead’s flood protection. The project will reduce flood extent and duration in the Model Land watershed and increase the Flood Protection Level of Service (FPLOS). Additional mitigation projects, including secondary canals and local drainage improvements, are proposed to reduce flood risks further.
- **C-103 and C-103N Canal Dredging Resiliency:** Dredging of C-103 and C-103N Canals to restore their original design capacity, enhancing drainage efficiency and flood protection. This project benefits Homestead, Miami-Dade County, and surrounding areas, providing improved flood control for over 180,000 residents.
- **S-20G Coastal Structure Resiliency:** Reinforced concrete spillway near Homestead (about 8 miles east), designed to manage upstream water levels and prevent saltwater intrusion into the Military Canal. Planned improvements include hydraulic gate upgrades, automation enhancements, and flood stage control improvements.

Flood Hazard Control Ordinance

The City of Homestead has implemented a comprehensive Flood Hazard Control Ordinance to mitigate flood risks and protect its residents and properties. This ordinance, detailed in Chapter 6, Article VIII of the city's Code of Ordinances, establishes development regulations within designated flood-prone areas. A key component of the ordinance is requiring all new constructions and substantial improvements to existing structures to obtain appropriate permits, ensuring compliance with flood-resistant building standards. Additionally, the ordinance mandates that these structures be elevated to a minimum of one foot above the Base Flood Elevation (BFE), thereby reducing potential flood damage. The city actively participates in the National Flood Insurance Program (NFIP), which enables residents to access federally backed flood insurance. Through the Community Rating System (CRS), Homestead has implemented measures exceeding the NFIP's minimum requirements, resulting in discounted flood insurance premiums for property owners.

Enforcement of the ordinance is overseen by the designated Floodplain Administrator, who is responsible for reviewing permit applications, conducting inspections, and ensuring adherence to all floodplain management regulations. The ordinance also emphasizes the importance of maintaining natural floodplain functions, such as wetlands and open spaces, which are crucial in absorbing floodwaters and reducing flood velocities. To prevent obstructions in these areas, the city prohibits illegal dumping into water bodies and drainage systems, imposing penalties for violations. Residents are encouraged to stay informed about their property's flood zone designation by consulting the Flood Insurance Rate Maps (FIRM) available through the city's Development Services Department or the Miami-Dade County Flood Zone Maps

5. Recommended Actions

The IN-CORE analysis offers critical insights into identifying high-risk areas and assessing the severity of flood impacts, enabling the development of more targeted and effective protection strategies. Based on these findings, along with existing mitigation and planning initiatives, it is evident that Homestead's flood resilience efforts must extend beyond FEMA-designated flood zones to address additional vulnerable areas identified in this study. To guide these efforts, Table 2 outlines key recommended actions to strengthen Homestead's flood resilience. Additionally, below is a list of potential funding sources available to support the implementation of these critical strategies.

Federal Level

- **HMGP – FEMA Hazard Mitigation Grant Program:** This program provides funding for projects that reduce risks from natural disasters, including retrofitting high-risk structures:
- **FMA—FEMA Flood Mitigation Assistance:** This program offers grants for flood mitigation activities, including elevation, acquisition, and floodproofing of buildings.
- **BRIC – Building Resilient Infrastructure and Communities:** This program offers Funds to proactive community resilience projects, including retrofitting vulnerable properties.

- **USDA Rural Development Water and Environmental Programs:** This program provides funding for stormwater-related projects in rural and unincorporated areas that could complement building retrofits.
- **NOAA Coastal Resilience Grants:** This program supports flood mitigation projects in coastal areas
- **EPA Water Infrastructure Finance and Innovation Act (WIFIA):** Provides low-interest loans for water infrastructure projects, including retention ponds and stormwater systems.
- **USDA Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP):** Funds conservation practices, including nature-based flood mitigation solutions.
- **Department of Housing and Urban Development (HUD) Grants**:
    - *Community Development Block Grant Disaster Recovery (CDBG-DR)* – Provides flexible funding for rebuilding efforts in disaster-affected areas.
    - *Community Development Block Grant Mitigation (CDBG-MIT)* – Supports strategic flood mitigation projects to reduce future risks.
- **New Federal Funding Programs**:
    - *Bipartisan Infrastructure Law (IIJA)* – Includes $50 billion for climate resilience, flood protection, and environmental justice programs.
    - *Inflation Reduction Act (IRA)* – Funds nature-based resilience solutions and provide grants for community resilience projects.

Key state funds include:

- **Resilient Florida Program:** Administered by the Florida Department of Environmental Protection (DEP), this program funds local and regional resilience projects, including flood control infrastructure, stormwater management, and sea-level rise adaptation.
- **Florida Forever Program:** A state-funded land acquisition and conservation initiative that helps protect floodplains, wetlands, and coastal buffer zones, reducing flood risks and enhancing natural resilience.
- **Rebuild Florida Mitigation Program:** Managed by the Florida Department of Economic Opportunity (DEO), this program provides disaster mitigation funding for stormwater improvements, infrastructure hardening, and flood risk reduction projects in disaster-prone areas.

- **Florida Small Cities Community Development Block Grant (CDBG) Program:** Offers funding to small municipalities for stormwater drainage improvements, floodplain management, and infrastructure upgrades to enhance resilience.
- **South Florida Water Management District (SFWMD) Cooperative Funding Program:** Supports stormwater management, wetland restoration, and flood mitigation projects, providing matching funds to local governments and water management districts.
- **Florida Office of Resilience and Coastal Protection Grants:** Funds coastal resilience initiatives, such as living shorelines, storm surge mitigation, and floodplain restoration, to reduce flood risks in coastal communities.
- **Florida Department of Transportation (FDOT) Resilient Roads Program:** Supports flood mitigation projects for transportation infrastructure, including stormwater drainage improvements and road elevation efforts in flood-prone areas.
- **Florida Water Infrastructure Improvement Program:** Provides funding for stormwater and flood control infrastructure projects to improve water quality and reduce flood risk across the state.

Table 2. Recommended Strategies

Action	Description	Potential Funding Source	Priority	Timeframe
Expand flood mitigation measures beyond FEMA Zones	Actively using the results of the current study to update zoning and land-use regulations to include areas identified as flood-prone in this study, ensuring they receive flood protection standards comparable to FEMA-designated flood zones.	General Funds	High	Short-term
Retrofitting buildings at high risk of complete or severe flood damage	Require higher elevation standards and enhanced drainage requirements for developments in areas shown in this report as vulnerable to severe and complete damage (DS2 and DS3). It is recommended increasing elevation requirement to 2-3 feet above the Base Flood Elevation (BFE) standards, implementing managed retreat strategies in the most vulnerable zones, and enforcing restrictions that allow new construction only if designed with elevated foundations and flood-resilient features.	CDBG-DR, HMGP	High	Short-term
Enhance stormwater management and drainage infrastructure	Implement stormwater retention and drainage system improvements, particularly in areas where flood depths exceed FEMA predictions.	BRIC, (DEP) Resilient Florida Program.	Moderate	Medium-term
Promote nature-based solutions for flood mitigation	Expand green infrastructure initiatives such as bioswales, permeable pavements, and wetland restoration to absorb floodwaters naturally.	National Coastal Resilience Fund (NFWF), Florida Forever Conservation Program.	Moderate	Medium-term
Strengthen building codes and resilient construction practices	Require flood-resistant building materials and elevated mechanical systems in all new developments where flood depths are expected to exceed 3 feet and adequate drainage upgrades are not in place. Provide incentives for property owners to retrofit existing structures with flood-resilient modifications to enhance long-term protection and reduce flood risks.	General Funds / Florida DEP/ Florida CDBG / Florida DEO / SFWMD Cooperative Funding Program	Moderate	Medium-term
Provide hazard specific checklists to residents and business owners	Use the current report to disclose public information regarding flood depth as well as areas and buildings that are at risk of moderate flood damage. Awareness about hazards can minimize future damages	General Fund	High	Short-term

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Appendices

Appendix A. IN-CORE Methodology

In order to run an IN-CORE building damage analysis, information about the local building stock is required. To build this dataset, the publicly available data from the National Structures Inventory (NSI) is typically utilized. This data has information on the structure type and size, foundation type and height, and number of stories. This data is used to determine the most appropriate building flood archetype for each structure. Some uncertainty arises at this stage as the NSI makes necessary assumptions to populate missing records. The quality of this dataset at the local level should always be considered. The flood archetype assignment process bins all buildings into one of 15 possible building archetypes (Table 3), which are assumed to behave similarly under hazard loading. In the case of flood, these archetypes were developed in order to effectively predict the structural and non-structural damage caused by a given flood depth on different types of buildings. The full list of building archetypes and their defining characteristics was put forth in the work of Omar Nofal and John W. van de Lindt in the peer-reviewed paper Minimal Building Flood Fragility and Loss Function Portfolio for Resilience Analysis at the Community Level (2020) and has been referenced in several subsequent publications.

Table 3. A reproduction of the tabulated archetypes
Source: Nofal and van de Lindt (2020)

Building Archetype	Building Description
F1	One-story single-family residential building on a crawlspace foundation
F2	One-story multi-family residential building on a slab-on-grade foundation
F3	Two-story single-family residential building on a crawlspace foundation
F4	Two-story multi-family residential building on a slab-on-grade foundation
F5	Small grocery store/Gas station with a convenience store
F6	Multi-unit retail building (strip mall)
F7	Small multi-unit commercial building
F8	Super retail center
F9	Industrial building
F10	One-story school
F11	Two-story school
F12	Hospital/Clinic
F13	Community center (place of worship)
F14	Office building
F15	Warehouse (small/large box)

With buildings sorted into the most appropriate archetype category and archetypical building damage determined by flood depth, a flooding scenario in the form of mapped flood depths is the final element required to run a building damage analysis with IN-CORE. The mapped flood depths used in these analyses have been developed from mid-century climate projections generated by Argonne National Laboratories, purchased by AT&T, and provided to Project IN-CORE by AT&T for the development of use cases of the climate data available on the Climate Risk and Resilience Portal (ClimRR). A version of this data will be available in short order on the ClimRR portal. The flood depths shown for this analysis represent a 100-year flood depth along the coastline and a 50-year pluvial flooding event inland in the mid-century decade of 2045-2054. The coastal flood dataset captures the increase in storm surge under sea-level rise scenarios compounded by hurricane and tropical storm events. Meanwhile, the inland pluvial flooding dataset captures the non-stationarity of intense rainfall events across the United States.

ClimRR provides peer-reviewed climate datasets in a nontechnical format and puts high-resolution, forward-looking climate data into the hands of those who need them most. Community leaders and public safety officials can now understand how changing climate risks will affect the populations they serve. Access to this information will assist leaders as they strategically invest in infrastructure and response capabilities to protect communities for future generations. ClimRR has been made publicly available at no cost by Argonne, AT&T, and FEMA to enable greater climate resilience among local communities.

These datasets are immensely helpful in understanding possible future flooding conditions; however, they do not reflect riverine flooding, nor do they capture municipal stormwater systems. For fluvial (riverine) flooding information, FEMA flood maps remain a good source of information. Meanwhile, for urban flooding, engaging in a more in-depth stormwater analysis may be necessary. The results below are provided to support this understanding of the bounds of the analysis.

Building the Damage Analysis: Running the Model and Obtaining Results

As described above, the building damage analysis is run by taking a set of buildings, binning them into 15 archetypical building categories, simulating a flood across the region of interest, and then determining the predicted damage level in accordance with these input factors. Upon running this analysis, you will note the term Damage State (DS) is used to denote varying levels of damage. In the latest version of IN-CORE, damage states are defined as DS0, DS1, DS2, and DS3. This is not in direct alignment with previously mentioned work and the figures shown below. This is because the most up-to-date version of IN-CORE has simplified the damage state prediction by grouping the slight damage category of “DS1” with the insignificant damage category of “DS0.” Thus, in Figure 6, the original table of anticipated functionality from Nofal and van de Lindt (2020) has been annotated to show the new damage states and how they map to the original ones.

	DS Level	Functionality	Damage Scale	Loss Ratio
DS0	DS0	Operational	Insignificant	0.00–0.03
	DS1	Limited Occupancy	Slight	0.03–0.15
DS1	DS2	Restricted Occupancy	Moderate	0.15–0.50
DS2	DS3	Restricted Use	Extensive	0.50–0.70
DS3	DS4	Restricted Entry	Complete	0.70–1.00

Figure 6. Anticipated functionality by damage state according to Nofal and van de Lindt (2020) and augmented to align with the outputs of up-to-date IN-CORE models

Building Functionality Analysis: Defining Damage Probabilities

If the community experiences this event only once, our primary concern would be structures with a probability exceeding 50% of reaching Damage State 2 or 3. This would represent an impactful result for those structures with only a single occurrence of the modeled hazard event. However, global climate models suggest that the flooding event shown in this report will occur with greater frequency as we progress through this century. Thus, there becomes a greater level of concern with not only buildings in the DS2 and DS3 levels but also buildings in the DS1 level that will see a wearing down of their functionality as similar events become more common. As such, we have highlighted two scenarios. The first is the scenario where this event happens a single time, and the second is where this event happens frequently enough to degrade a larger portion of the building stock through repeated exposure. We have chosen to provide both of these scenarios because the flood depths we used for modeling do not represent a worse-case scenario for the local community but rather an event that the community should be very much expected to experience and successfully withstand in the coming years and possibly on multiple occasions. These two thresholds are superimposed onto Archetype 1's set of fragility curves in Figure 11 below. Thus, the following damage probability values do not represent damage probabilities due to separate events but rather serve to explore the possibility of how the flooding event described above would have varied impact if it occurred habitually versus a single time. The reality will likely be somewhere between these two scenarios.

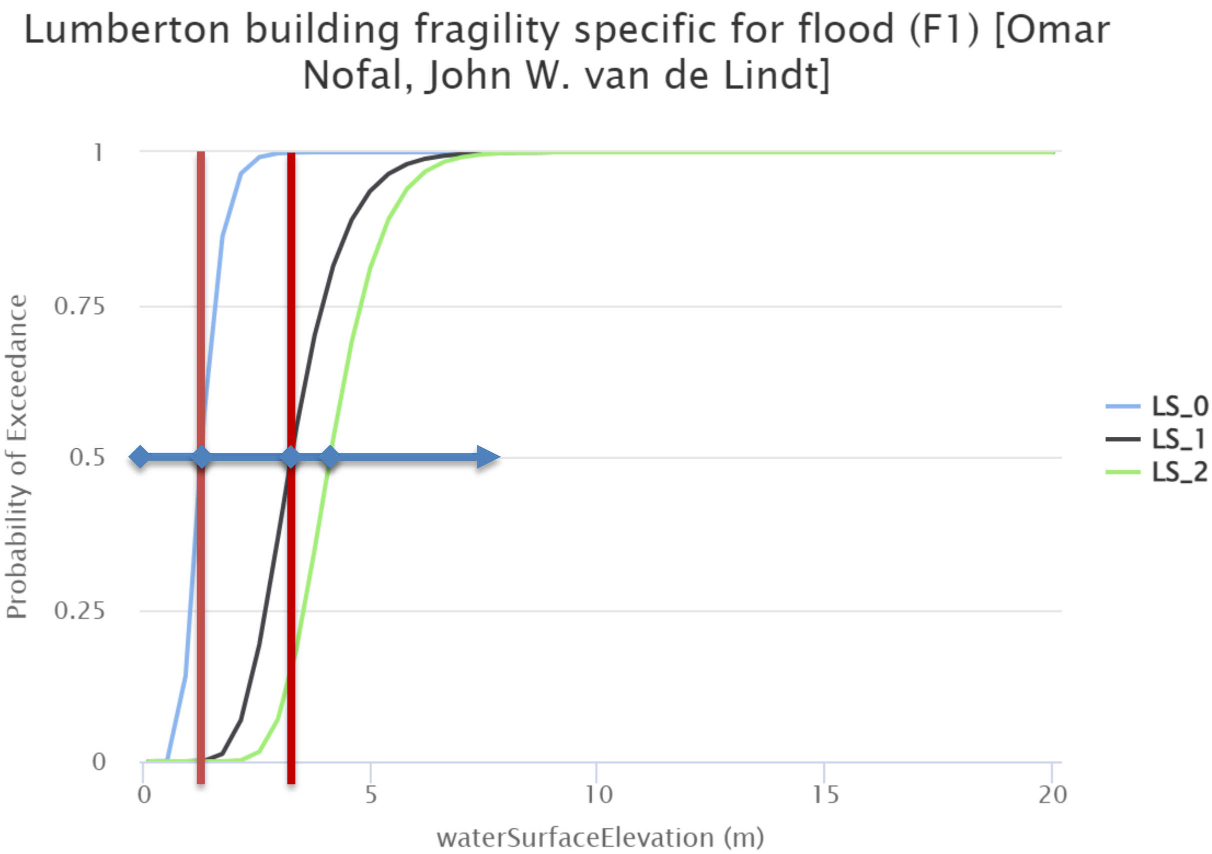

Figure 7. An example set of fragility curves to demonstrate the failure thresholds defined for this analysis
Source: Nofal and van de Lindt (2020)

Appendix B. Sourcing the Necessary Data to Run an IN-CORE Population Dislocation Analysis

The dislocation model requires data on people as well as on structures. To generate the housing unit population allocation, a separate python package called Pyncoda developed as part of the Center of Excellence for Risk-Based Community Resilience Planning, is used to synthetically allocate households to housing units. The demographic characteristics of the synthetic population matches the characteristics at the Census block group level. This work is described as follows by Pyncoda's README file on GitHub authored by Nathanael Rosenheim et al. (2022).

People are the most important part of community resilience planning. However, models for community resilience planning tend to focus on buildings and infrastructure. This repository provides a solution that connects people to buildings for community resilience models. The housing unit inventory method transforms aggregated population data into disaggregated housing unit data that includes occupied and vacant housing unit characteristics. Detailed household characteristics include size, race, ethnicity, income, group quarters type, vacancy type, and census block. Applications use the housing unit allocation method to assign the housing unit inventory to structures within each census block through a reproducible and randomized process. The benefits of the housing unit inventory include community resilience statistics that intersect detailed population characteristics with hazard impacts on infrastructure, uncertainty propagation, and a means to identify gaps in infrastructure data such as limited building data. This repository includes all of the Python code files. Python is an open-source programming language, and the code files provide future users with the tools to generate a 2010 housing unit inventory for any county in the United States. Applications of the method are reproducible in IN-CORE (Interdependent Networked Community Resilience Modeling Environment).

Population Dislocation Analysis: Running the Model and Obtaining Results

Once a housing unit allocation has been generated, then the damage result for each building can be combined with the social data for each household, such as tenure status, race, and household income, to determine whether a household is likely to temporarily relocate due to a hazard event, in this case a flood. The results of a population dislocation analysis can be analyzed further to understand the equity impacts of such hazards.