UNDERSTANDING FLOOD SCENARIOS: A ROADMAP TO RESILIENCE LIBERTY COUNTY, GA

PROJECT REPORT 2025-002

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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.

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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.

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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, Georgia, North Carolina, and South Carolina, focusing on Community Disaster Resilience Zones.

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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. 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 presents a comprehensive flood resilience analysis for Liberty County, Georgia, to inform policy decisions and guide resilience planning strategies. The analysis evaluates future flood hazard scenarios, identifying areas within the community vulnerable to current and mid-century flooding. Considering the increasing frequency and intensity of precipitation, the study highlights evolving risks to help policymakers and stakeholders plan effectively for climate impacts. The overarching goal of this report is to support the County's capacity to navigate urban growth and flood risk uncertainties, fostering a resilient and adaptive community.

This study also analyzes flood vulnerabilities within Liberty County's three Community Disaster Resilience Zones (CDRZ) since they represent opportunities for integrating resilience planning into broader community development efforts. Addressing flood risks within CDRZs ensures that these areas remain viable for growth and investment while also aligning with state and federal priorities for resilience funding.

The analysis was conducted using the IN-CORE platform (www.in-core.org), incorporating its Flood Damage Analysis model, Population Dislocation Model, and Computable General Equilibrium (CGE) model. 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

Liberty County, Georgia, located along the southeastern U.S. coast, is home to approximately 65,000 residents (Census, 2023). The county includes seven municipalities (Figure 1): Hinesville (34,891 residents), Walthourville (3,680 residents), Midway (2,141 residents), Riceboro (615 residents), Flemington (825 residents), Allenhurst (816 residents), and Gum Branch (235 residents), as well as portions of Fort Stewart, one of the largest U.S. Army installations. The County’s economy and demographics are significantly influenced by the presence of Fort Stewart and its role as a regional hub for development. The entire County, along with a portion of Long County, is included in the Hinesville Area Metropolitan Planning Organization (HAMPO), the federally designated body responsible for transportation planning and funding allocation in the region. In the last 15 years, Liberty County experienced seven presidentially declared disasters, as stated below:

- **Hurricane Helene (September 2024):** On September 30, 2024, it was issued a major disaster declaration for Georgia, including Liberty County, following the impacts of Hurricane Helene. This declaration provided federal assistance for recovery efforts in the affected areas.
- **Tropical Storm Debby (August 2024):** In response to Tropical Storm Debby, which affected Georgia from August 4 to August 20, 2024, a major disaster declaration was approved on September 24, 2024. Liberty County was among the

counties eligible for federal assistance to support recovery from the storm's impacts.

- **Hurricane Michael (October 2018):** On October 14, 2018, it was declared a major disaster for Georgia due to Hurricane Michael. Liberty County was included in the designated areas eligible for federal assistance to aid recovery efforts.
- **Hurricane Irma (September 2017):** On September 15, 2017, a major disaster declaration for Georgia was approved, following the impacts of Hurricane Irma. Liberty County was among the counties eligible for federal aid to support recovery from the hurricane.
- **Hurricane Matthew (October 2016):** In response to Hurricane Matthew, a major disaster declaration was issued for Georgia on October 8, 2016. Liberty County was included in the areas eligible for federal assistance.
- **Southeastern Floods (September 2009):** Severe flooding in September 2009 led to a major disaster declaration for parts of Georgia. While Liberty County was not among the initially designated counties, the widespread nature of the disaster impacted many areas in the state.

These repeated events underscore the county's vulnerability to natural hazards, exacerbated by its coastal location and evolving climate conditions. While specific assessments of Liberty County's resilience foundation vary, its proactive engagement in regional planning initiatives and access to federal resources reflect an ongoing commitment to enhancing its capacity to adapt to and recover from climate-related impacts.

Liberty County has four Community Disaster Resilience Zones (CDRZ), shown in (Figure 1). These zones were established under the Community Disaster Resilience Zones Act of 2022, which amended the Stafford Act to enhance the Federal Emergency Management Agency's (FEMA) ability to identify and support areas most at risk from natural disasters. Signed into law on December 20, 2022, the act empowers FEMA to designate CDRZs based on comprehensive assessments of disaster risk and community vulnerability. By designating these zones, the legislation ensures that resources, funding, and technical assistance are strategically directed to areas where they are most needed, enabling communities to better prepare for, respond to, and recover from disasters. The areas indicated in Figure 1 labeled as Areas 1 through 4, correspond to the following census tracts:

- **Area 1 (Census Tract 13179010208)**: Encompasses parts of Hinesville, Walthourville, and a portion of the unincorporated area of Liberty County.
- **Area 2 (Census Tract 13179010402)**: Includes portions of Allenhurst, Hinesville, Flemington, and unincorporated areas of Liberty County.
- **Area 3 (Census Tract 13179010302)**: Covers Hinesville and a small portion of Flemington.

- **Area 4 (Census Tract 13179010501)**: Contains a small section of Midway and unincorporated areas of Liberty County.

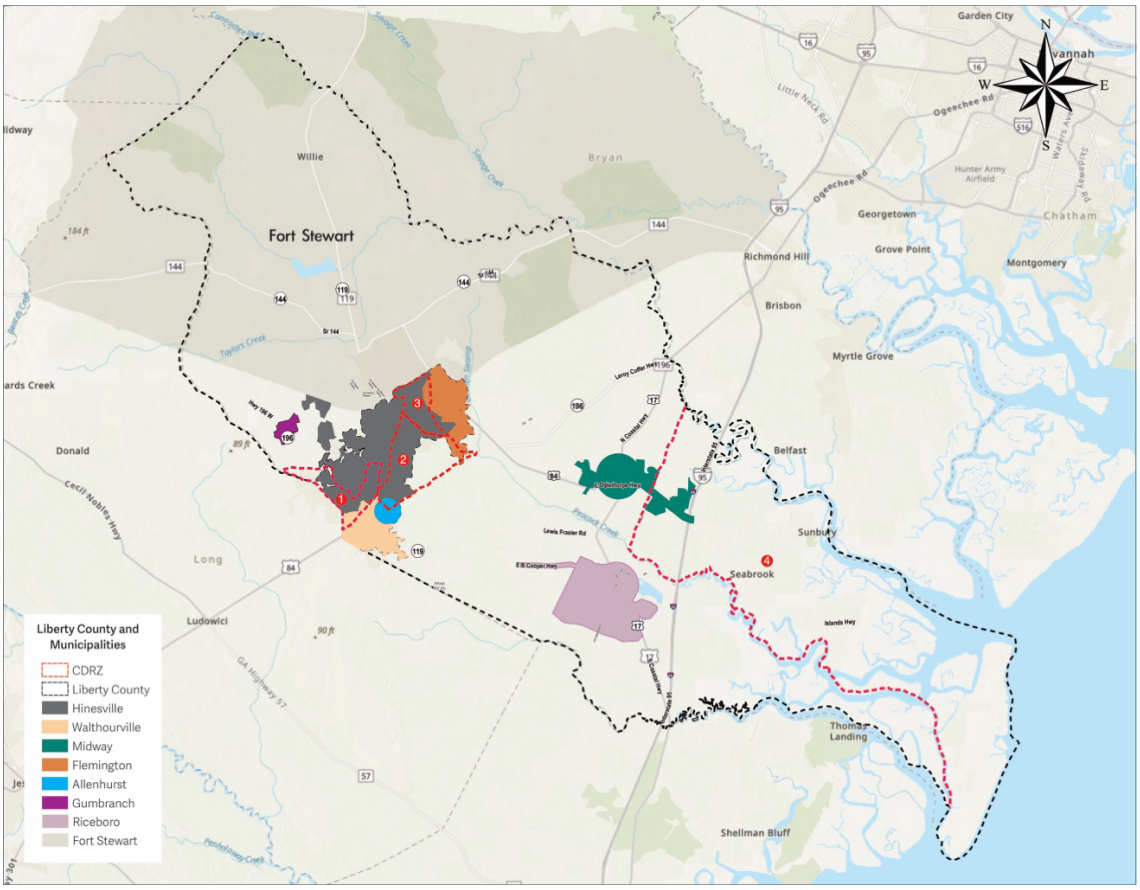

Figure 1. Municipalities within Liberty County
Source: Developed based on Liberty Consolidated Planning Commission and FEMA CDRZ

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 on 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 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. Or there are 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, highlighting that while low-level damage (Damage State 1) is expected for approximately 9.13% of buildings, only around 82 buildings are likely to experience moderate to severe damage (Damage States 2 or 3). The results highlight only buildings with a probability greater than 50% of being damaged within each category. Figure 2 and Figure 3 show the areas in which those buildings are concentrated, which can also be accessed in this link. The flood depths used in our modeling represent realistic events

that the local community is likely to encounter and should be prepared to withstand repeatedly in the coming years rather than a worst-case scenario. Appendix A provides more details on the methodology.

Table 1: Summary of the building damage analysis – Liberty County

Damage State	Building Count	% of Buildings
Damage State 0	23067	90.55%
Damage State 1	2326	9.13%
Damage State 2	76	0.30%
Damage State 3	6	0.02%

Source: IN-CORE

Figure 2 highlights the priority areas where buildings face a significant risk of severe damage (DS2) or complete damage (DS3). Additional details can be explored by selecting the Extensive Damage Probability (DS2-DS3) layers in the Liberty County IN-CORE Analysis app for a more in-depth analysis.

One of the most vulnerable areas in Liberty County is Halfmoon Landing, particularly the vicinity surrounding Cattle Hammock Road. This is included within CDRZ #4 (Figure 2). This area contains a mix of elevated and non-elevated structures, with the modified NSI dataset potentially not fully capturing the precise elevation of every structure (see Appendix A for details on the methodology). Given the flood depth in this region, which ranges from 5 to 14 feet for certain structures—significantly exceeding the levels observed in most other parts of the county—strict mitigation strategies are essential. These should include measures such as elevating existing structures, implementing managed retreats in high-risk zones, and restricting new construction to elevated designs only. With numerous lots for sale in the area, careful planning is critical to minimize future flood risks and promote long-term resilience.

Drum Point Landing, Billy Harris Point, and other properties along these estuaries are also located within CDRZ #4 (Figure 2). While this region is exposed to flooding, its lower population density reduces the overall impact compared to more densely populated areas. However, projected flood depths in this region range from 3 to 10 feet around Islands Highway, which could result in temporary road closures and significant connectivity issues. As the primary roadway serving these communities, any disruption to the Island's Highway could hinder access to essential services and emergency response efforts, emphasizing the need for proactive flood mitigation strategies.

Other areas within CDRZ #4, including Limerick, Isle of Wight, and Dorchester, are projected to experience varying flood depths ranging from 3 to 10 feet. This region is particularly vulnerable due to the presence of multiple bodies of water. To mitigate flood risks, the area would benefit from adaptive land use development and distributed water management practices. Key strategies include preventing overdevelopment, upsizing retention ponds, and implementing nature-based solutions to minimize erosion along the rivers and streams that traverse the region. These measures would help dissipate flood depths and enhance the area's resilience to future flooding events.

The neighborhood surrounding Liberty County High School in Flemington, while not located within any designated CDRZ, is projected to experience damage from pluvial flooding. Floodwaters in this area could potentially reach depths of up to 5 feet in the vicinity immediately adjacent to the neighborhood. However, due to the granularity of the flood data, the significant elevation variations within the affected grid cell, and the proximity to the nearest waterway, the actual flood depth in this community may be lower. Consequently, building modifications are not needed. Instead, we suggest prioritizing regular maintenance of water management infrastructure, such as culverts, and implementing improvements where needed. This may include upsizing water conveyance systems or increasing water storage capacity along Alligator Creek to better manage future flood risks.

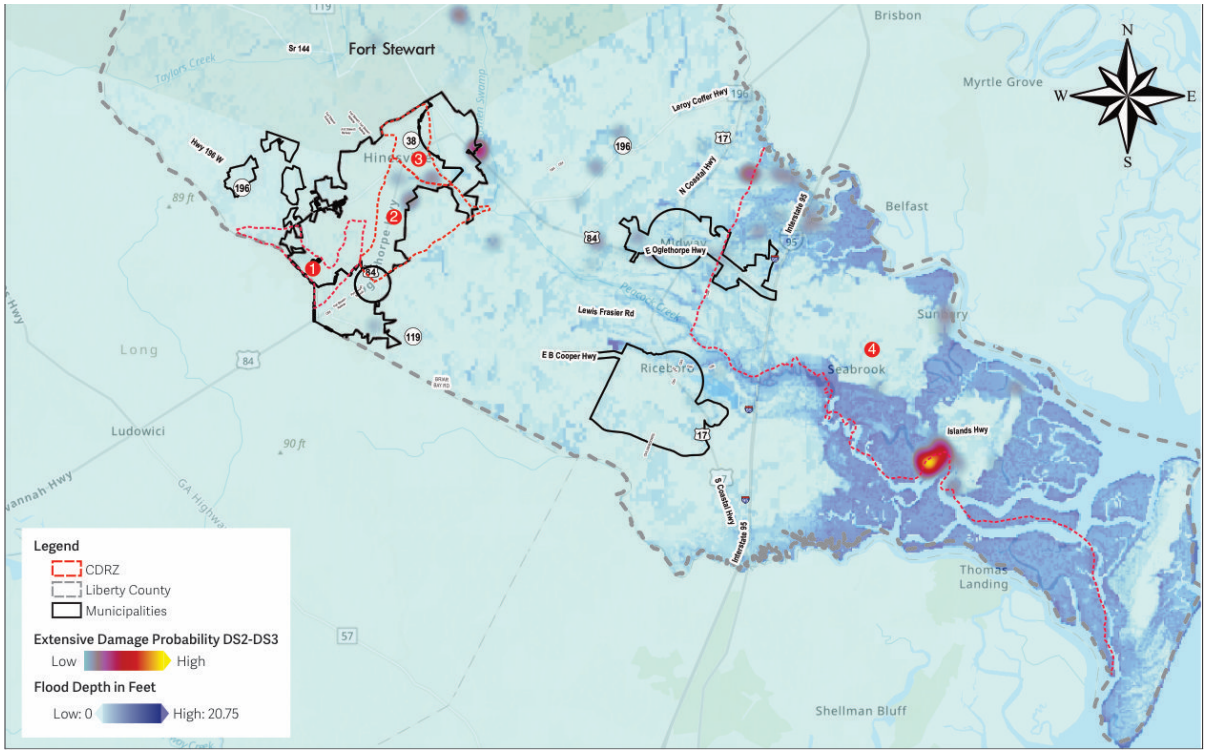

Figure 2. Areas with the probability of experiencing Damage State 2 and 3
Source: Liberty County IN-CORE Analysis app

While DS 1 represents moderate damage, the immediate priority in a single flood would be structures with a greater than 50% probability of reaching DS 2 or 3. However, global climate models indicate that flooding events described in this report will likely become more frequent as the century progresses. With repeated flood events, structures currently in DS 1 should also be a concern, as ongoing exposure could gradually compromise the functionality and structural integrity of a larger portion of the building stock over time (Figure 3).

In areas expected to experience lower-level damage, such as CDRZ #1 in Hinesville (around Rye Patch Road and Lynn Court), CDRZ #2 in Hinesville (around Belle Arbor and Courtland), CDRZ #4, as well as other areas in Midway, Walthourville, and unincorporated parts of Liberty County (as shown on Figure 3), proactive flood management strategies are recommended. These strategies include avoiding utility installations in flood-prone crawlspaces, installing sump pumps in areas where low-level flooding is projected to be more common, and landscaping to divert heavy precipitation away from building foundations. Additionally, nature-based solutions, such as enhancing infiltration and preventing erosion along rivers, streams, and coastlines, can play a critical role. These measures can help mitigate cumulative impacts and improve long-term resilience.

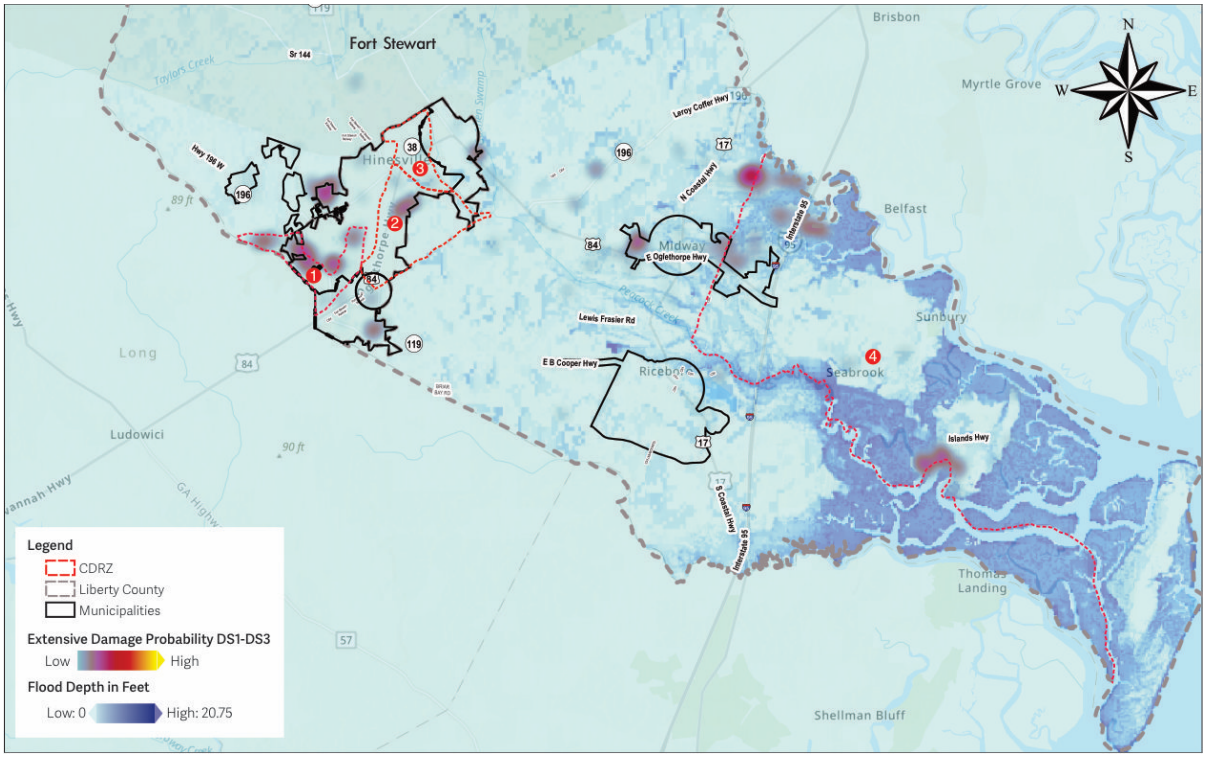

Figure 3. Areas with the probability of experiencing Damage State 1 to 3
Source: Liberty County IN-CORE Analysis app

3.2. 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. 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 demographic characteristics of the synthetic population match 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 (2021).

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 4 shows dislocated households in Liberty County after a simulated hazard event. This analysis yielded a dislocation of approximately 1550 households, representing about 6% of the households' census data. Details of this procedure can be found in the population dislocation methodology section (Appendix B). Minimizing damaged areas will also minimize population dislocation.

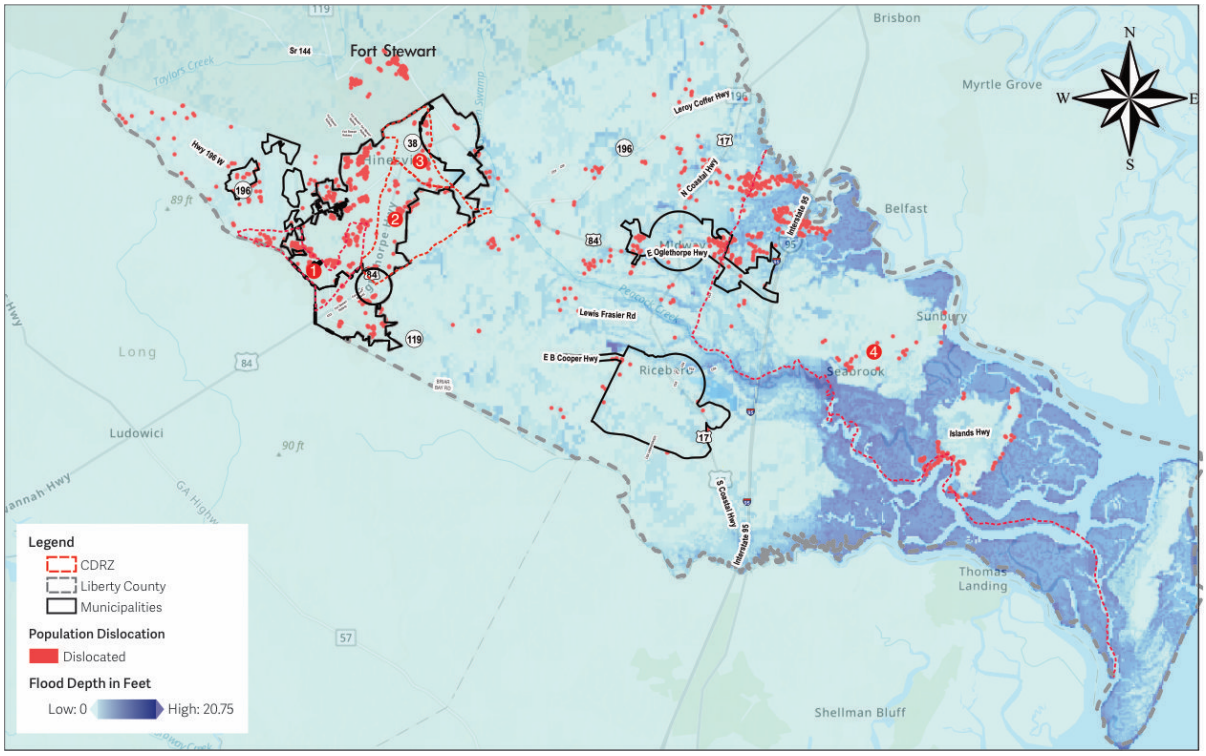

Figure 4. Population Dislocation
Source: Liberty County IN-CORE Analysis app

3.3. Economic Impacts

Flood events disrupt local economies, damage infrastructure, and reduce productivity. These impacts can ripple across sectors, affecting not only directly impacted industries but also supply chains and consumer behavior. To analyze such effects comprehensively, we used Computable General Equilibrium (CGE) models to simulate the interdependencies of economic sectors within Liberty County, capturing the systemic effects. A CGE model represents the economic relationships among producers, households, and the government, using economic theory to demonstrate the effects of economic changes on these entities. These models are centered on a Social Accounting Matrix (SAM), which tracks the transactions and income flows between households, firms, and government agents. A more in-depth explanation of CGE models is available in Appendix C.

The dominant industries in Liberty County (Figure 5) are Commercial (22.4%), Health (15.1%), Retail (12.1%), Leisure & Hospitality (13%), and Manufacturing (10.8%). The Commercial sector encompasses wholesale trade, transportation, finance and insurance, real estate, professional services, management, and administrative support.

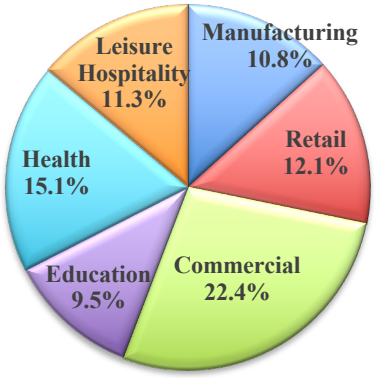

Figure 5. Employment share distribution across major economic sectors, 2022
Source: U.S. Bureau of Labor Statistics

The distribution of workers by race and ethnicity across four key economic sectors (Figure 6) reveals distinct patterns. The Commercial sector consistently records the highest employment levels across most wage categories, particularly for White workers in the $40,000 to $70,000 income range (Figure 6). Leisure and Hospitality, meanwhile, constitute a significant portion of employment for Black workers, with concentrations in the $15,000 to $40,000 wage bracket. The Retail sector, although present across all racial and ethnic groups, has relatively lower employment figures in all wage categories. Similarly, the Construction sector accounts for a smaller share of employment, with limited representation in higher wage categories. Overall, employment in the Commercial and Leisure and Hospitality sectors is predominant for both White and Black workers, whereas Retail and Construction contribute less significantly. A more detailed

analysis of the workforce across income levels, racial and ethnic groups, and economic sectors can be found in Appendix C.

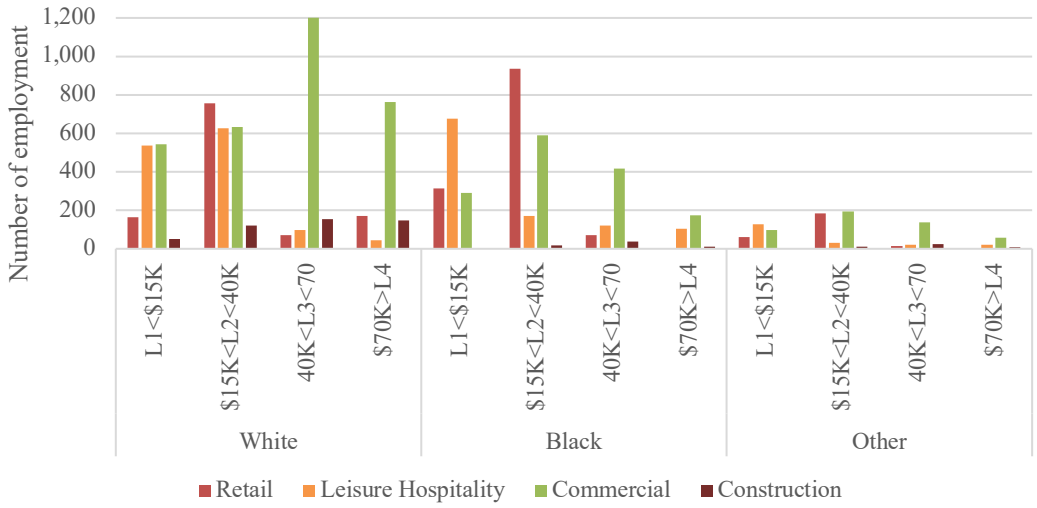

Figure 6. Distribution of workers by race and ethnicity across selected economic sectors, 2022
Source: U.S. Bureau of Labor Statistics

The labor movement in and out of Liberty County is illustrated in Figure 7. The number of residents commuting out of the county for work is nearly double that of individuals who both live and work within the County. This highlights Liberty County's role in supporting the economies of neighboring areas through the outflow of local workers. Simultaneously, it underscores the dependence of many county residents on employment opportunities beyond its borders for their wage income.

Figure 7. Inflow/Outflow analysis, Liberty County
Source: U.S. Census Bureau, 2021

The process of estimating economic damage using a CGE model is outlined in Figure 8. The process begins with engineers assessing how likely buildings are to become non-functional during a hazard. These probabilities are then used to estimate the loss in property value or "capital stock" within each economic sector by averaging the damage across buildings. This loss is treated as an external shock in the CGE model, which calculates the broader economic impact. The losses to capital stock (represented as delta K) lead to a decline in economic output (delta Y). As output drops, businesses may need fewer workers, causing employment to decrease. This reduction in employment impacts household income, both from wages and returns on investments. In essence, the loss of capital stock triggers a chain reaction affecting the local economy.

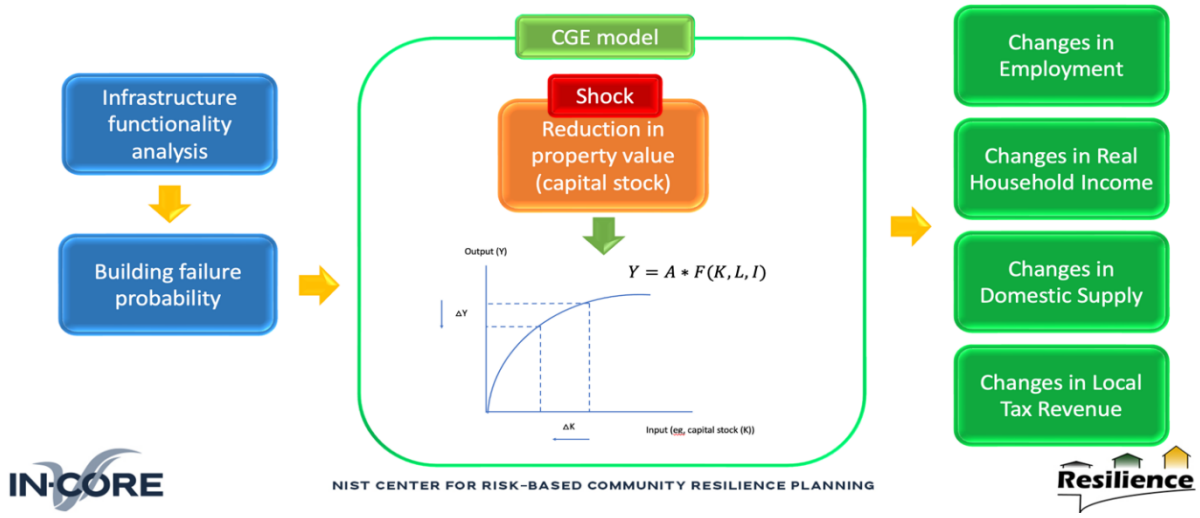

Figure 8. Integrating damage analysis into the CGE model

Figure 9 shows the analysis of two scenarios. The first, the DS2 threshold, defines failure as DS2 (severe damage) or higher (complete damage), focusing on structures impacted by one-time severe flooding. The second, the DS1 threshold, sets failure at DS1 (moderate damage) or higher (severe and complete damage), capturing structures more prone to frequent, lower-level flooding.

Under the DS2 threshold, the impact on real household income across all racial/ethnic groups and income brackets is relatively moderate, with declines less than 0.5%. However, under the DS1 threshold, the reductions are considerably more substantial, especially for high-income households (Figure 9). Other racial groups face the most significant declines, particularly those in the highest income range (earning over $100,000), where reductions in real household income approach -6%. White and Black households also experience notable, though slightly less severe, declines, especially in the highest income brackets (earning over $100,000), with drops exceeding 4%. The lowest-income groups (earning less than $30,000) across all racial categories are less impacted, with declines remaining under -1.5%. This pattern is largely influenced by extensive damage to housing services. While numerous economic sectors sustain considerable damage from flooding, the effect on household income for Liberty County residents might be less severe, given

that a significant number of them work outside the county. However, damage to housing services affects household income in two specific ways. First, elevated rental or temporary housing expenses lead to a reduction in real household income. Second, a decrease in property values leads to lower capital income, especially impacting higher-income households. As higher-income earners typically possess more property and rely more on capital income than labor income, damage to their housing units results in notable decreases in their capital income.

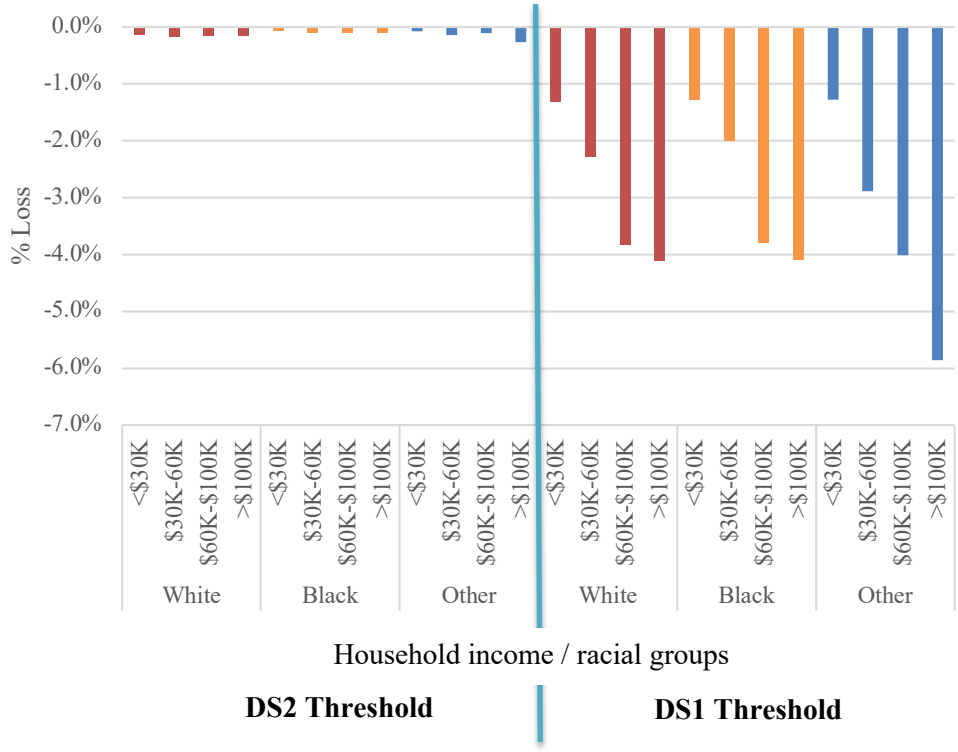

Figure 9. Effects on distribution of real household income

Table 2 provides an overview of property damage from flooding across various economic sectors, evaluated in the two different thresholds. At the DS2 threshold, total property damage reaches $73.77 million, corresponding to a 0.5% loss in overall property value. Notably, the Leisure Hospitality and Retail sectors would suffer considerable damage, incurring losses of 2.6% and 2.2%, respectively. At the DS1 threshold, reflecting more frequent and less severe flooding reveals a more extensive overall impact, with total property damage increases to $1.6 billion and an 11.8% decrease in property value. The Leisure Hospitality and Retail sectors would face substantial impacts, with losses of 11.6% and 10.6%, respectively. The Housing Services sector, particularly in housing units with higher values (HS3 and HS4), records the highest loss percentage, with 13.9% and 12.7% of properties affected, respectively.

Table 2. Property damage impacts of flooding

Economic sector	Total property value (millions of $)	DS2 Threshold		DS1 Threshold	
		Property damage (millions of $)	% loss	Property damage (millions of $)	% loss
Mining Utility	18.0	-0.1	-0.5%	-1.8	-9.8%
Construction	66.5	-0.8	-1.2%	-3.6	-5.5%
Manufacturing	89.6	-0.4	-0.4%	-5.5	-6.1%
Retail	294.9	-6.5	-2.2%	-31.1	-10.6%
Commercial	849.4	-12.0	-1.4%	-69.7	-8.2%
Transportation	264.2	-0.1	-0.1%	-18.6	-7.0%
Education	149.7	-0.6	-0.4%	-11.0	-7.4%
Health	220.5	-5.7	-2.6%	-25.7	-11.6%
Leisure Hospitality	300.8	-1.3	-0.4%	-23.6	-7.9%
HS1<10K	1,644.7	-8.9	-0.5%	-173.0	-10.5%
10K≤ HS2<20K	472.6	-3.0	-0.6%	-65.9	-13.9%
20K≤ HS3<40K	9,162.9	-34.4	-0.4%	-1,164.4	-12.7%
40K ≥HS4	13,533.7	-73.77	-0.5%	-1,593.84	-11.8%
Total	18.0	-0.1	-0.5%	-1.8	-9.8%

4. Current Planning Initiatives for Flood Resilience

Liberty County has undertaken several planning initiatives to enhance flood resilience in response to its vulnerability to coastal and inland flooding. These efforts include integrating flood risk mitigation into the county's comprehensive plan and zoning regulations, which guide development away from high-risk areas. The county actively participates in the National Flood Insurance Program (NFIP) and has adopted higher regulatory standards to reduce future flood risks. In addition, Liberty County collaborates with the Hinesville Area Metropolitan Planning Organization (HAMPO) to incorporate resilience into transportation planning, ensuring critical infrastructure remains operational during and after flood events. This section reviews key plans and ordinances related to flood resilience, emphasizing areas identified as risk in future flood hazard analyses section.

Liberty County Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) 2021

The 2021 Liberty County Multi-Jurisdictional Hazard Mitigation Plan aims to reduce the risks and vulnerabilities associated with natural hazards, particularly flooding, across Liberty County and its municipalities. It identifies hazards, assesses risks, and develops actionable mitigation strategies to protect lives, property, and critical infrastructure. It aligns with FEMA and Georgia Emergency Management Agency (GEMA) guidelines to enhance community resilience and secure eligibility for pre- and post-disaster funding. The plan incorporates stakeholder input, detailed hazard analyses, and risk assessments to prioritize mitigation projects and foster a collaborative approach to disaster preparedness.

The report's main findings emphasize the significance of coastal flooding and storm surge risks exacerbated by climate change, along with the need to address vulnerabilities in critical infrastructure and residential areas. Recommendations include implementing green infrastructure solutions, updating floodplain management practices, and revising land-use policies to discourage development in high-risk flood zones. Additionally, the plan highlights the importance of public education, stakeholder collaboration, and leveraging federal and state funding sources, such as FEMA's Hazard Mitigation Grant Program (HMGP) and the Building Resilient Infrastructure and Communities (BRIC) program, to support these initiatives.

The MJHMP established 12 goals, and this current report (PR – 2025-002) contributes directly to five out of the 12 goals. Specifically, it contributes to **Goal 2** by providing detailed and accurate flood hazard data to support mitigation planning, preparedness, and recovery operations. It addresses **Goal 3** by integrating the study's findings into planning and decision-making processes to improve emergency management and preparedness activities. It also supports **Goals 4, 8, and 9** by focusing on strategies to minimize risks to life and property from coastal hazards and flooding.

Liberty County 2040 Joint Comprehensive Plan

The 2020-2040 Liberty County Joint Comprehensive Plan outlines a long-term vision for growth and development across Liberty County and its municipalities. The goal of the plan is to provide a comprehensive strategy to guide future land use, housing, transportation, economic development, and natural resource management. Through detailed analysis and stakeholder engagement, the plan identifies current challenges and opportunities while setting priorities for addressing the community's needs over the next two decades.

The plan emphasizes the importance of managing growth to balance economic development with environmental preservation and quality of life. Recommendations include promoting mixed-use development, improving transportation networks to enhance connectivity, supporting economic diversification, and preserving green spaces to maintain the County's character. The plan also encourages the integration of local cultural and historical assets into

development strategies to strengthen the sense of community and attract sustainable investment. These strategies aim to ensure Liberty County's future growth aligns with the needs and aspirations of its residents.

Future Land Use

By analyzing the future land use maps proposed by Liberty County and its municipalities, in conjunction with the data from this report, which identifies areas with a high probability of moderate to severe flood damage, most areas are designated as low-density residential. These zones encourage a variety of compatible housing options, including single-family detached homes, duplexes, townhomes, and mobile homes, while also allowing secondary land uses such as parks and recreational facilities, adult and childcare facilities, office and light commercial spaces, educational facilities, and religious assemblies. New developments within these zones are required to implement buffering measures to control visual, noise, and activity impacts between residential and commercial uses. However, no recommendation is given to flood-prone areas.

For the areas identified as vulnerable to DS1 to DS3 (Figure 3, pg. 9), adopting proactive flood management strategies is crucial. These include avoiding utility installations in flood-prone crawlspaces, installing sump pumps in areas where low-level flooding is projected to occur more frequently, and utilizing landscaping techniques to divert heavy precipitation away from building foundations. These measures not only enhance the resilience of new developments but also mitigate the risks associated with increased flood exposure.

Flood Damage Prevention Ordinance

The Liberty County Multi-Jurisdictional Hazard Mitigation Plan provides general floodplain management standards to the county municipalities with broader guidelines. It mentions that new structures in Special Flood Hazard Areas (SFHAs) must comply with FEMA's National Flood Insurance Program (NFIP) regulations, requiring elevation at or above the Base Flood Elevation (BFE). Our study indicates that there are also vulnerable areas to flood outside the SFHA.

The Liberty County Code of Ordinances, Chapter 8, Article III mentions Flood Damage Prevention. The goal is for new constructions within areas of special flood hazards in the unincorporated areas of Liberty County to be designed to minimize flood damage. Therefore, where base flood elevation data are available, new construction and/or substantial improvement of any structure or manufactured home shall have the lowest floor, including basement, elevated no lower than one foot above the base flood elevation. In special flood hazard areas without base flood elevation data, new construction and substantial improvements of existing structures shall have the lowest floor of the lowest enclosed area (including the basement) elevated no less than three feet above the highest adjacent grade at the building site.

5. Recommended Actions

The IN-CORE analysis provides valuable insights into identifying areas at risk and assessing the severity of impacts, enabling more effective protection strategies. Preventing development in high-risk areas is often more cost-effective than implementing mitigation measures. Therefore, integrating risk assessments into planning processes is crucial. To address these challenges, we recommend the actions presented in Table 3.

It is important to mention that some of the recommended strategies are within CDRZs, which offer significant advantages when pursuing grants and external funding. Designated CDRZ areas are prioritized for resilience-building activities, as they highlight communities with heightened vulnerability to natural hazards and the greatest need for mitigation and adaptation efforts. These areas often align with the funding priorities of federal programs such as FEMA's BRIC and FMA, HUD's CDBG-MIT, and state-level resilience initiatives. Projects in CDRZs not only address critical vulnerabilities but also strengthen grant applications by demonstrating alignment with federal and state resilience goals, ensuring that investments target the most impactful solutions. Below is a list of potential funding sources available at various levels.

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.

State Level

- **GEMA/HS – Georgia Emergency Management and Homeland Security Agency:** This program administers FEMA's HMGP and BRIC funding at the state level and provides technical assistance to local governments.
- **GEFA – Georgia Environmental Finance Authority:** This program offers grants and low-interest loans for projects that improve environmental resilience, including stormwater management and building retrofits.
- **CIGP—Georgia Coastal Incentive Grant Program:** This program provides funding for coastal resilience projects, including flood mitigation and retrofitting in coastal communities.
- **CDBG – Georgia Community Development Block Grants:** Administered by the Georgia Department of Community Affairs, these funds can be used for resilience-focused improvements, including retrofitting structures in low- and moderate-income communities.
- **Georgia Department of Natural Resources (DNR) Coastal Resources Division Grants:** Supports projects that mitigate flooding impacts in coastal areas, including retrofitting vulnerable properties.

Table 3. Recommended Strategies

Jurisdiction	Action	Description	Potential Funding Source	Priority	Timeline
Unincorporated areas of Liberty County Hinesville Walthourville Flemington Midway	Use this current study to establish base flood elevation standards in building codes and floodplain damage prevention ordinance	Actively using the results of the current study to establish and enforce base flood elevation data for new construction, considering the impacts of climate change. By taking this approach, cities can directly address flood risks, promote safer building practices, and enhance resilience in flood-prone areas. The data flood depth raster layer available in the Liberty County IN-CORE Analysis app.	Local funds	High	Short-term
Unincorporated areas of Liberty County	Retrofitting buildings at high risk of complete or severe flood damage	Retrofitting buildings at high risk of complete or severe flood damage in areas around Halfmoon Landing and vicinity surrounding Cattle Hammock Road, which are included within CDRZ #4 (Figure 2). With flood depths in this region ranging from 5 to 14 feet, recommended measures include elevating existing buildings to at least 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.	CDRZ zone HMGP / FMA / BRIC / USDA / NOAA / GEMA / GEFA / CIGP /CDBG / Georgia DNR	High	Short-term
Unincorporated areas of Liberty County	Promote flood mitigation in high-risk estuarine areas	Promote flood mitigation in areas around Drum Point Landing, Billy Harris Point, and other properties along the estuaries within CDRZ #4 (Figure 2). Projected flood depths in this region range from 3 to 10 feet, particularly around Islands Highway, posing a risk of temporary road closures and significant connectivity challenges. As the primary roadway serving these communities, any disruption to Islands Highway could hinder access to essential services and emergency response efforts. Therefore, proactive flood mitigation strategies are necessary, including elevating critical sections of the roadway, enhancing drainage systems, and implementing protective measures to reduce flood impacts on surrounding properties and infrastructure.	CDRZ zone HMGP / FMA / BRIC / USDA / NOAA / GEMA / GEFA / CIGP /CDBG / Georgia DNR	High	Short-term

Jurisdiction	Action	Description	Potential Funding Source	Priority	Timeline
Unincorporated areas of Liberty County	Promote flood mitigation through adaptive land use	Areas within CDRZ #4, including Limerick, Isle of Wight, and Dorchester, are projected to experience varying flood depths ranging from 3 to 10 feet, due to their proximity to multiple bodies of water. Recommended strategies include implementing adaptive land use development to prevent overdevelopment in high-risk zones, upsizing retention ponds to improve stormwater storage capacity, and adopting nature-based solutions to reduce erosion along rivers and streams.	CDRZ zone HMGP / FMA / BRIC / USDA / NOAA / GEMA / GEFA / CIGP /CDBG / Georgia DNR / WIFIA / EQIP	Moderate	Medium-term
Flemington	Promote flood mitigation through maintenance and improvement of water management infrastructure	This action focuses on improving water management infrastructure in the neighborhood surrounding Liberty County High School in Flemington to mitigate pluvial flooding risks. Although the projected flood depths of up to 5 feet are likely overestimated due to elevation variations and proximity to waterways, proactive maintenance and upgrades are essential to manage future flood risks. Key measures include conducting regular maintenance of culverts to ensure optimal water flow, upsizing water conveyance systems to handle increased stormwater volumes, and expanding water storage capacity along Alligator Creek.	HMGP / FMA / BRIC / USDA / NOAA / GEMA / GEFA / CIGP /CDBG / Georgia DNR / WIFIA / EQIP	Moderate	Medium-term
Unincorporated areas of Liberty County Hinesville Midway Walthourville	Implementing Proactive Flood Management Strategies in Low-Damage Areas	This action aims to enhance flood resilience in areas projected to experience lower-level flood damage, including CDRZ #1 in Hinesville (around Rye Patch Road and Lynn Court), CDRZ #2 in Hinesville (around Belle Arbor and Courtland), CDRZ #4, and other parts of Midway, Walthourville, and unincorporated Liberty County. Recommended strategies include avoiding utility installations in flood-prone crawlspaces, installing sump pumps in areas prone to low-level flooding, and employing landscaping techniques to divert heavy precipitation away from building foundations. To complement these efforts, nature-based solutions such as enhancing soil infiltration and preventing erosion along rivers, streams, and coastlines should be implemented.	CDRZ zone Local funds HMGP / FMA / BRIC / USDA / NOAA / GEMA / GEFA / CIGP /CDBG / Georgia DNR / WIFIA / EQIP	Moderate	Medium-term

Jurisdiction	Action	Description	Potential Funding Source	Priority	Timeline
Unincorporated areas of Liberty County Hinesville Walthourville Flemington Midway	Integrating Flood Resilience into Future Land Use Planning	This action focuses on incorporating flood resilience measures into the future land use plans for Liberty County and its municipalities, particularly in areas with a high probability of moderate to severe flood damage currently designated as low-density residential. While these zones promote a mix of compatible housing and secondary uses no specific guidance has been provided for vulnerable flood areas. Therefore, the current study should be used to directing development away from high-risk areas and integrating flood mitigation strategies into planning policies.	Local funds	High	Short-term
Unincorporated areas of Liberty County Hinesville Walthourville Flemington Midway	Discourage Development in High-Risk Areas	The flood depth in certain areas of Liberty County ranges from 3 to 15 feet. Flood depths of **6 feet or more** are generally considered extremely hazardous for construction, as they pose significant risks to life safety, structural integrity, and emergency access. Therefore, the County and its municipalities should strongly discourage development in regions where flood depths exceed 6 feet. The data flood depth raster layer available in the Liberty County IN-CORE Analysis app.	Local funds	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 4), 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 4. A reproduction of the tabulated archetypes

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)

Source: Nofal and van de Lindt (2020)

It is important to note a unique situation that Liberty County encountered in the analysis. The NSI dataset for Liberty County drastically overestimated the number of elevated structures in this area, so a modification has been made to the NSI dataset to create a more representative inventory. Under this modification, structures outside the FEMA 100-year flood plain with 8-ft elevation listed were assumed to be inaccurate and converted to 0.5-ft foundation height and slab-on-grade foundations. Elevated structures from the NSI dataset that fell within FEMA 100-year floodplain were left as elevated structures in the modified dataset.

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 that 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 10, 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 10. 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 only has to experience this event a single time, then we would primarily be concerned with those structures that have surpassed of 50% probability of being in a 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.

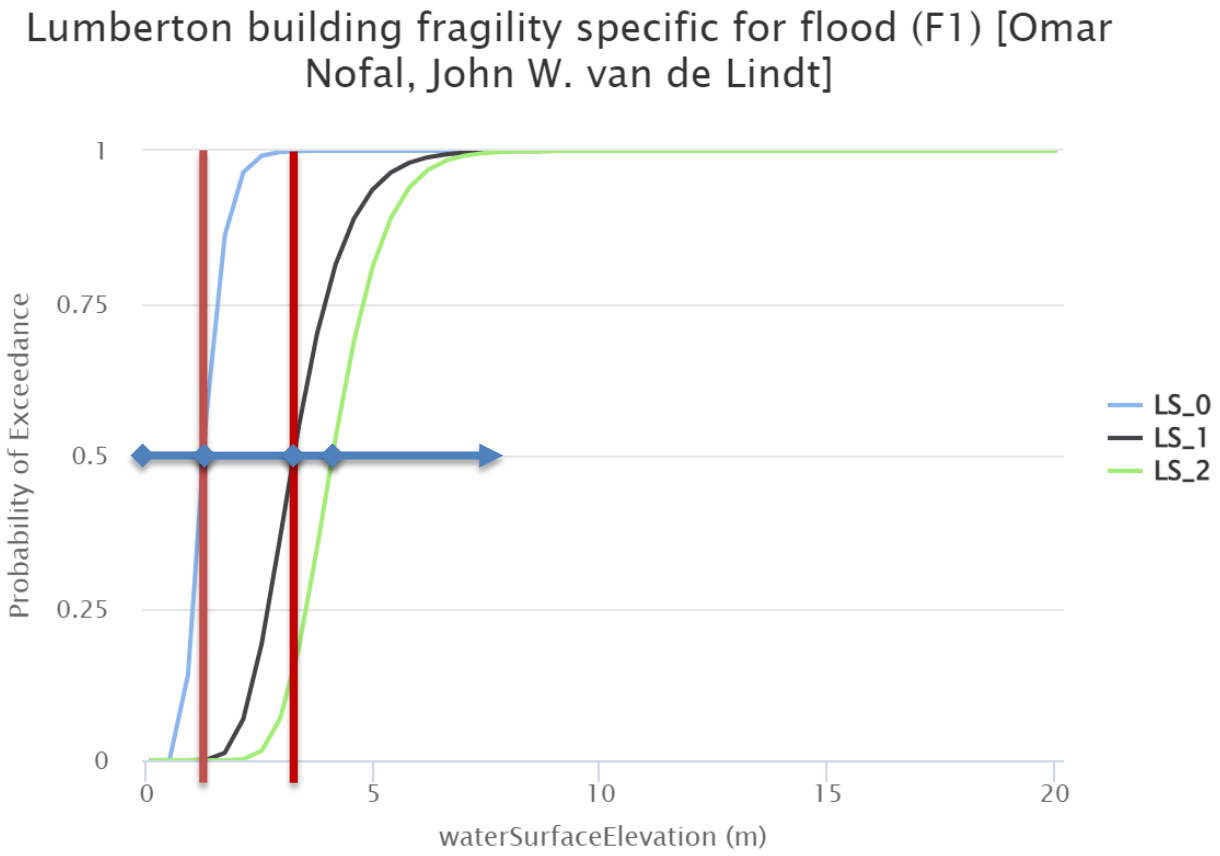

Figure 11. An example set of fragility curves to demonstrate the failure thresholds defined for this analysis
Source: Nofal and van de Lindt (2020)

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:

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.

Appendix C. The Computable General Equilibrium Model (CGE) for Liberty County

Liberty County has a diverse employment distribution across income levels, racial and ethnic groups, and economic sectors. A Computable General Equilibrium (CGE) model represents the economic relationships among producers, households, and the government, using economic theory to demonstrate the effects of economic changes on these entities. These models are centered on a Social Accounting Matrix (SAM), which tracks the transactions and income flows between households, firms, and government agents. The SAM documents the resource flows shown in Figure 12, utilizing data from multiple sources

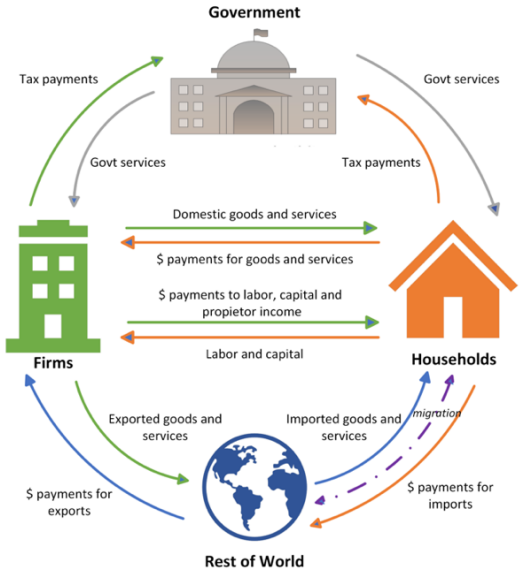

Figure 12. Structure of Computable General Equilibrium Model
Source: Amini et al. (2023)

Figure 12 illustrates the fundamental modeling framework using a circular flow diagram. Households contribute labor, entrepreneurship, and capital, earning income through wages, profits, and returns on investments. This income is then distributed among consumption, taxes, and savings. Profit-oriented firms produce and sell goods and services, utilizing both local and imported inputs such as labor, capital, and intermediate goods. Governments, in turn, use tax revenue collected from households and firms to provide various public goods and services. Source: Amini et al. (2023). The CGE model also accounts for trade between a community and other places which we call "Rest of the World".

Figure 13 illustrates a visual representation of the Liberty County SAM, along with brief descriptions of its key components.

	Economic sector	Labor groups	Capital	Households	Housing services	Taxes	Government	ROW
Economic sector	Intermediate purchases			Household expenditure			Government expenditure	Export
Labor groups	Wage payments by fimrs						Wage payments by government	
Capital	Capital payments				Capital payments			
Households		Wage transfer to households						
Housing services				Housing expenditure				
Taxes	Tax payments			Tax payments				
Government						Tax transfer to government		
ROW	Imports							

Figure 13. Detailed Liberty County SAM

The demand for intermediate inputs is derived from input-output coefficients for two-digit North American Industry Classification System (NAICS) sectors, determined by IMPLAN (Economic Impact Analysis Software) data. Employment is estimated by race and ethnicity across four wage groups and is aggregated into two-digit NAICS sectors using the Census Longitudinal Employer-Household Dynamics dataset (LEHD) and PUMS (Public Use Microdata Sample). The wage payments by firms and government matrices are constructed from worker incomes obtained from the U.S. Census Bureau's PUMS, which are then aggregated by sector. Wage transfers to households refer to the distribution of wage payments from labor groups to their respective household groups. Household and income data are sourced from PUMS, while household spending patterns are estimated using IMPLAN values adjusted with the Bureau of Labor Statistics' Consumer Expenditure Survey. Capital stock values for buildings are estimated based on data from the National Structure Inventory (NSI) provided by the U.S. Army Corps of Engineers, which includes detailed information on property types, building values, and spatial coordinates. Government tax revenue and expenditures are drawn from Liberty County's Annual Comprehensive Financial Report. The import and export matrices outline the payments made by sectors and households in Liberty County to sectors in other regions and vice versa. From a microeconomic standpoint, a household's income and expenditures must balance within its budget constraint, meaning total income should equal total expenditures, including consumption, taxes, and savings. A reduction in real household income due to factors like job losses or inflation can lead to economic downturns. On the macroeconomic level, transactions between sectors and economic agents must conform to standard aggregate accounting identities, such as Liberty

County's GDP equating to the sum of consumption, investment, government spending, and net exports.

As shown in Figure 14, Liberty County has a highly diverse workforce, with White employees making up 50.5%, representing just over half of the total employment. Black employment follows at 40.7%, while Other racial/ethnic groups make up the smallest portion at 8.8%. Notably, over 65% of workers in Black and Other groups earned less than $40,000 annually. As income levels increase, the proportion of White workers remains higher relative to the Black and Other groups.

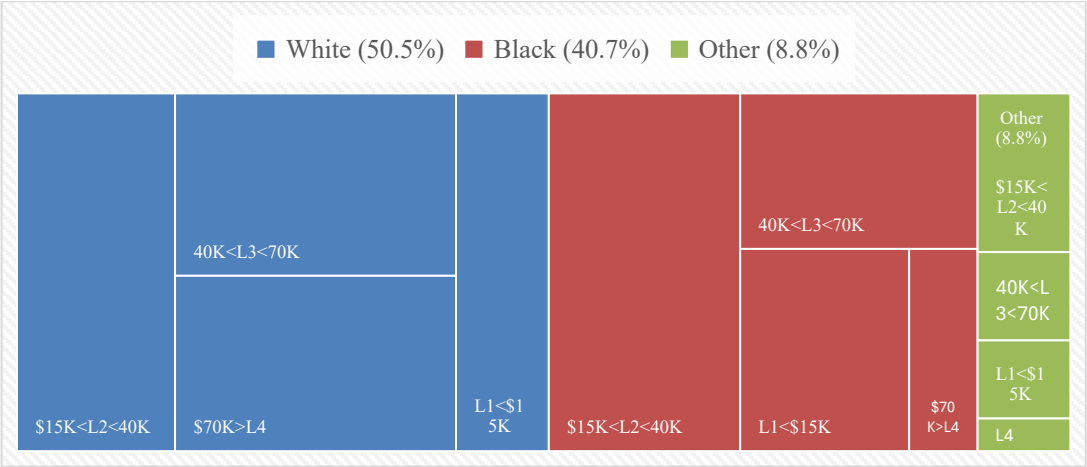

Figure 14. Distribution of workers by race and ethnicity across different income groups, 2022
Source: U.S. Bureau of Labor Statistics

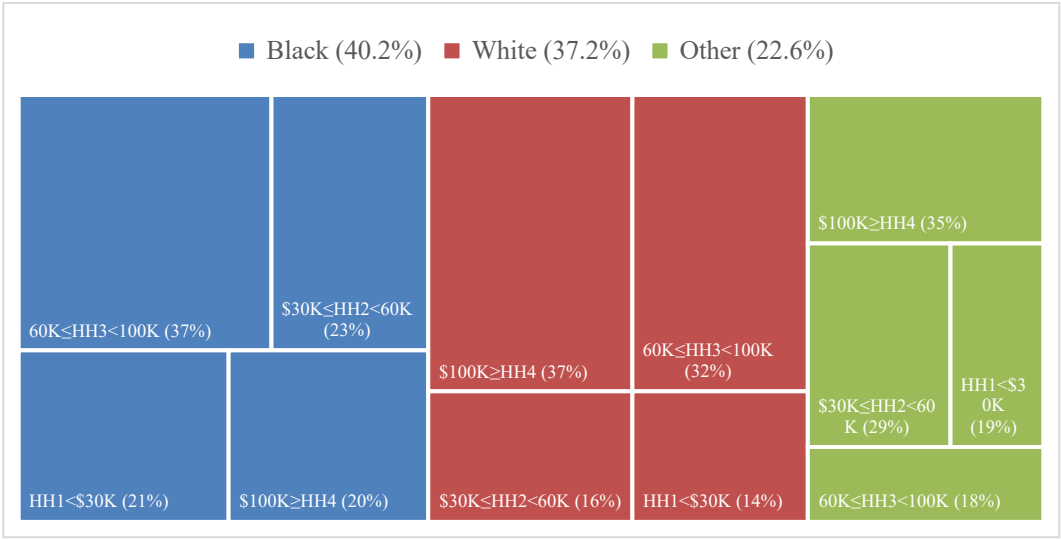

Figure 15. Distribution of households by race and ethnicity across different income groups, 2022
Source: U.S. Bureau of Labor Statistics

Economic Impact Channels

Civil engineers assess damage across various building types, including commercial, industrial, and residential structures. This damage—whether to structural, non-structural (architectural), or content components—leads to a reduction in the region's overall capital stock. The changes in residential and commercial capital stock are then aggregated by sector and expressed as a percentage decrease in the total capital stock within the region.

A reduction in capital stock within the commercial and industrial sectors has two main effects on domestic supply. First, diminished production capacity leads to a decrease in firms' output. Second, as capital becomes scarcer and its price increases, firms reduce their demand for it and shift toward greater reliance on substitutes, such as labor. These adjustments increase production costs, eroding the ability of businesses to compete both nationally and globally.

The impacts of reductions in housing capital can be modeled similarly. Housing serves two key functions: providing shelter and generating income through property value appreciation. Damage to housing capital directly reduces household income, which comprises labor and capital income. It is assumed that households in Liberty County own a substantial share of local firms. Therefore, when commercial capital is damaged, capital income decreases, leading to a decline in household income. Additionally, damage to residential properties reduces home equity, further eroding household income.

Changes in employment

Under the DS2 threshold, the impact on employment is relatively moderate, with most labor groups experiencing only small losses. In contrast, the DS1 threshold leads to more substantial employment losses, particularly in higher income brackets, with Black and Other groups seeing the most significant declines. Nonetheless, all labor groups face notable employment losses. This reflects the widespread damage to key sectors like Commercial, Retail, and Leisure Hospitality, which employ a large portion of the workforce. It is also important to note that these reductions affect not only households within Liberty County but also those in surrounding areas, as many workers commute into the county. In other words, the impact of flooding disrupts not only the local economy but also the economies of neighboring regions.

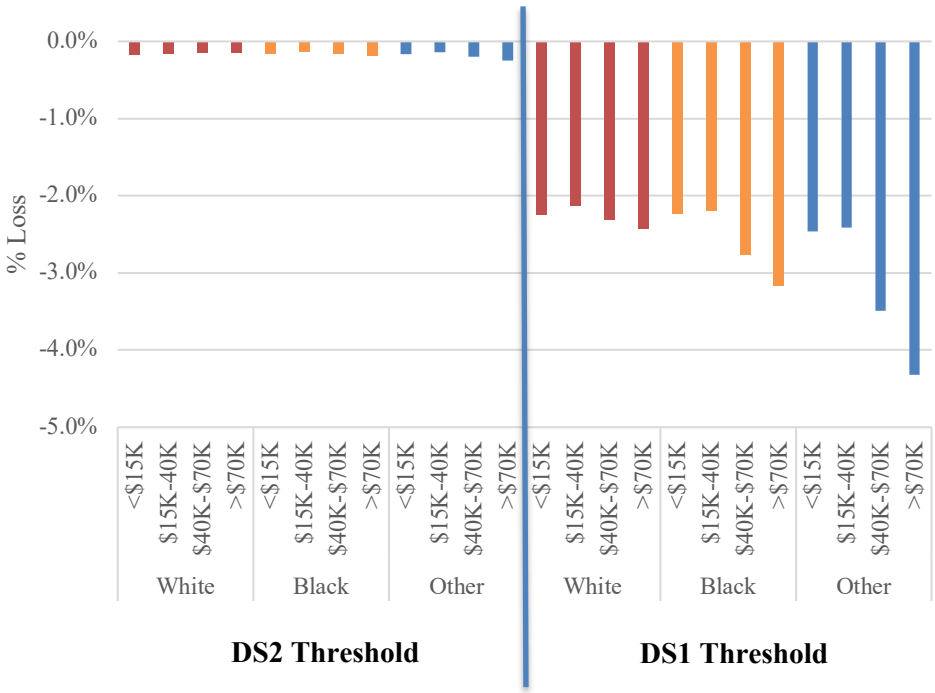

Figure 16. Effects on distribution of employment

Changes in domestic supply

Figure 17 displays the effects of flooding on sectoral domestic supply across various economic sectors. Under the DS2 threshold, the impact on most sectors is relatively mild, with decreases under 1%. However, under the DS1 threshold, the effects are significantly more severe and widespread. Several sectors, particularly Construction, Commercial, and Leisure Hospitality, experience sharp declines in domestic supply, with reductions exceeding 4%. Other sectors that are heavily impacted under DS1 include the higher-value housing service sectors (HS3 and HS4), which see declines around 10%. The findings suggest that in smaller towns, housing often constitutes a larger share of the local economy, notably in sectors like construction, real estate, and housing-related services. Consequently, damage to housing disproportionately affects these sectors, resulting in a more substantial impact on domestic supply.

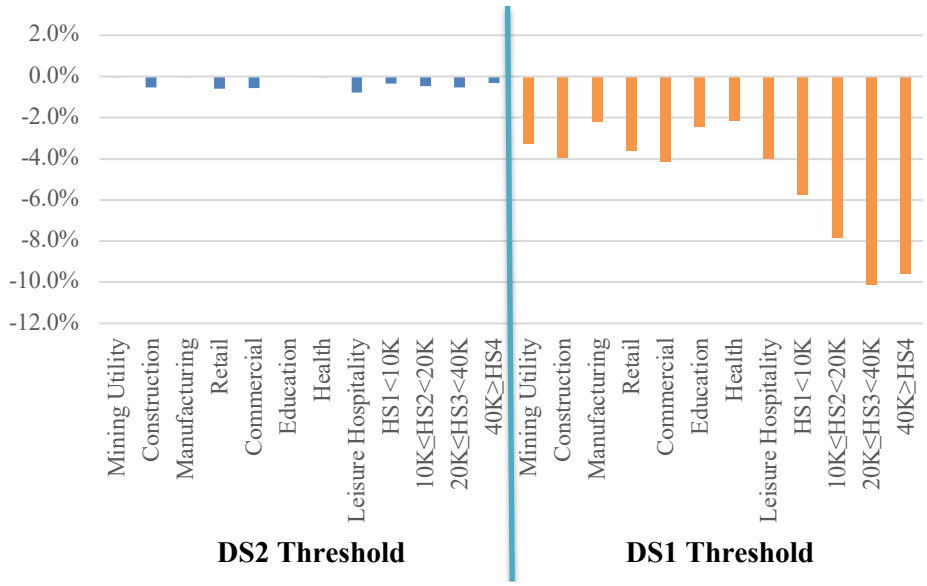

Figure 17. Effects on sectoral domestic supply

Changes in local tax revenues

In terms of local tax revenues (Figure 18), under the DS2 threshold, the impact on local tax revenues is quite modest, with declines of less than 0.1% across all tax categories. However, under the DS1 threshold, the impacts are significantly more pronounced. Property tax revenues see a sharp drop of nearly -1.8%, while sales and income taxes also face considerable reductions, with declines of approximately -0.7% and -1.1%, respectively. As noted earlier, Liberty County endured significantly more damage to housing services compared to the commercial and industrial sectors. Since property tax revenue is closely linked to the physical condition and valuation of real estate, the damage to housing units leads to a substantial decrease in property tax revenue.

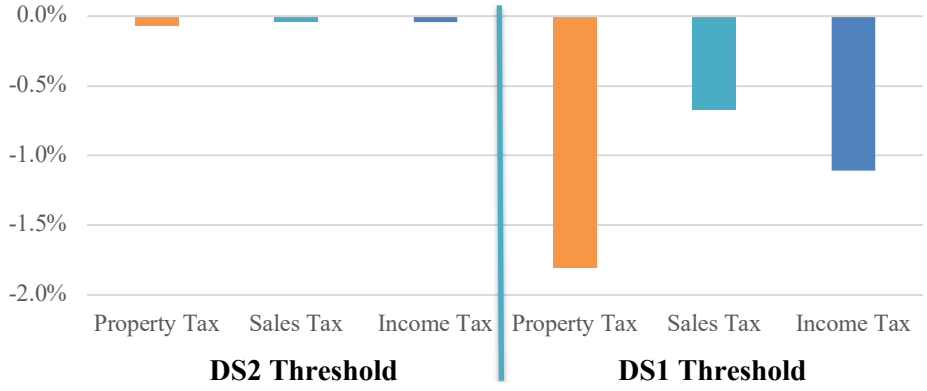

Figure 18. Effects on local tax revenues

This report details the projected economic impacts of flooding events in Liberty County, highlighting the anticipated costs and their distribution among various racial, ethnic groups, and economic sectors. The findings indicate that lower-level flooding significantly impacts both business and residential properties. The most extensive damage occurred in the higher-valued housing sectors, as well as in Leisure Hospitality and Retail, followed by the Mining Utility sectors. Given that Liberty County has a higher number of workers commuting in than those living and working within the county, disruptions in business sectors could lead to considerable household income reductions for non-residents, due to increased unemployment. Simultaneously, lower-level flooding severely affects the higher-value housing service sectors. The destruction of housing units results in increased housing expenses, which subsequently reduce real household income and trigger outmigration. These reductions in household income led to decreased spending on goods and services within the county, contributing to a cumulative local economic downturn. Therefore, retrofitting properties in high-risk areas could significantly mitigate unemployment losses and protect real household income, thus reducing the severity of flood damage and accelerating the county's recovery time.

It is important to acknowledge that our analysis covers only a subset of economic and distributional impacts. Although the findings indicate that more frequent, lower-level flooding may lead to more severe economic consequences, they should be evaluated in conjunction with the wider environmental and health-related costs linked to each flooding scenario. Flooding can cause significant environmental issues, including water contamination, habitat loss, and coastal erosion, all of which have considerable economic, health, and ecological repercussions.

Furthermore, our economic modeling is based on damage estimates that involve inherent uncertainties. The model depends on simplifying assumptions that might not capture the full complexity of human behavior and economic interactions. Therefore, the results should be regarded as approximations of possible outcomes based on the available data, rather than precise predictions.