

Key Drivers of Coastal Relocation in Spatial Clusters Along the U.S. East Coast

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Thesis submitted to the faculty of Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree

of

Master of Science

In

Geography

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June 20, 2024

Blacksburg, Virginia

Keywords: Coastal flooding, relocation drivers, spatial analysis, East Coast

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Abstract (Academic)

Coastal flooding has been increasing in frequency and severity across the US East Coast, adversely impacting the human population. Preferred adaptation strategies, such as protection and accommodation, may prove insufficient under current climate change scenarios and projected future sea level rise, prompting the coastal population to consider relocation as a more efficient disaster risk reduction strategy. This study focuses on the flood-prone urban areas along the US East Coast where residents are more willing to relocate due to coastal flooding. Using the survey data, it evaluates the flood experiences, considerations toward relocation, and preferences for relocation destinations. The extent of top concerns influencing respondents' willingness to relocate, such as crime rate, buyout programs, access to critical services and amenities, and availability of comparable housing, were further explored as indirect relocation drivers. Four study locations with heightened relocation potential were identified across urban areas on the US East Coast. Relocation drivers such as crime and limited access to services and amenities are not significantly present in these study locations. However, the absence of buyout programs and affordable housing options in similar communities leaves low-income households trapped in high-risk zones, exacerbating socioeconomic disparities, and increasing the disproportionate risk faced by marginalized populations. The findings have important implications for policymakers, urban planners, and stakeholders involved in climate adaptation and disaster risk reduction efforts. They highlight the need for targeted interventions to address socioeconomic vulnerabilities, promote equitable access to housing, and enhance the resilience of communities facing coastal hazards.

Key Drivers of Coastal Relocation in Spatial Clusters Along the U.S. East Coast

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Abstract (General audience)

Coastal flooding is increasing in both frequency and severity along the US East Coast, significantly impacting local populations. Traditional adaptation strategies, such as building protective structures and making accommodations, may not be sufficient under current climate change scenarios and projected sea level rise. Consequently, some coastal residents are considering relocation as a more effective strategy for reducing disaster risk. This study focuses on flood-prone urban areas along the US East Coast, where residents are more inclined to relocate due to coastal flooding. Using survey data, it assesses their flood experiences, considerations towards relocation, and preferred relocation destinations. The study also examines indirect factors influencing the willingness to relocate, such as concerns about crime rates, buyout programs, access to essential services and amenities, and the availability of comparable housing. The research identifies four study locations of urban areas with a high potential for relocation. In these study locations, issues such as crime and limited access to services and amenities are less significant. However, the absence of buyout programs and affordable housing options in similar communities traps low-income households in high-risk zones, exacerbating socioeconomic disparities and increasing the disproportionate risk faced by marginalized populations. These findings have significant implications for policymakers, urban planners, and stakeholders involved in climate adaptation and disaster risk reduction. They highlight the need for targeted interventions to address socioeconomic vulnerabilities, promote equitable access to housing, and enhance the resilience of communities facing coastal hazards.

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Preface/ Attribution

Dr. Anamaria Bukvic was the committee chair and academic advisor for this manuscript. She provided guidance and support throughout the research process, such as developing research objectives and managing the workflow. Her experience in coastal resilience and adaptation was integral to this research.

Dr. Kim Junghwan was a committee member who guided the geospatial applications and statistics used in the methodology of this research.

Dr. Tom Crawford was a committee member who guided the methodology and statistical analysis of this research. His background in coastal geography and human-environment interactions was integral to this research.

Chapter 1: Literature Review

Key Drivers of Coastal Relocation in Spatial Clusters Along the U.S. East Coast

1.1. Introduction

The coastal communities and environment are highly vulnerable to extreme weather events and the sea level rise caused by climate change. By 2060, about 1.4 billion people will reside in the coastal area worldwide (Dawson et al., 2018). The damages to the coastal population and environment have been exacerbated in recent years due to their vulnerability to climate change-induced disasters such as hurricanes, flooding, storm surges, sea-level rise, and the increasing population residing in the coastal areas (Busayo and Kalumba, 2020). The episodic flooding and permanent inundation of low-lying coastal environments are also predicted to worsen due to the sea level rise (Addo et al., 2011). According to NOAA, the most frequent natural disasters occurring in the coastal communities are floods, with one in three federal disasters being declared as related to flooding (NOAA,2024).

1.2. Vulnerability of the US East Coast

The US East Coast is one of the nation's most vulnerable coastal regions with densely populated urban areas experiencing accelerated high tide flooding at 80% of NOAA tide gauge locations (NOAA, 2022). According to the US Army Corps of Engineers (USACE), the shoreline in the North Atlantic region is changing in response to sea level change, evident from the exacerbated historic erosion patterns (USACE, 2015). The low relief of the East Coast also makes it more susceptible to inundation (Gornitz et al., 1994), with increased minor tidal flooding [defined as 0.3 m above MHHW (mean higher high water)] in recent years for most coastal locations from the

Gulf of Maine to Florida (Ezer and Atkinson, 2014). For example, the projected sea level rise (SLR) will lead to significant increases in flood heights of tropical cyclones in New York City, causing a decrease in flood height return periods from approximately 500 years during the preindustrial era to around 25 years in recent years (Garner et al. 2017). Similarly, an estimated 1% to 3% of the land area of New Jersey is anticipated to experience permanent inundation within the next hundred years, while coastal storms are expected to temporarily inundate low-lying regions up to 20 times more frequently (Cooper et al., 2005).

Additionally, the intensity of hurricanes approaching the US East Coast may increase in the future due to weakened vertical wind shear (VWS) stemming from greenhouse gas emissions, allowing hurricanes to intensify more rapidly (Ting et al., 2019). VWS is crucial in regulating Atlantic hurricanes, particularly when decreasing, thereby creating favorable conditions for more hurricane activity. The warming of the Florida ocean current has also contributed to accelerating SLR between Key West and Cape Hatteras and created favorable conditions for recurrent flooding (Domingues et al., 2018). The annual average exposure (AAE) to flooding caused by climate change on the East Coast is also expected to intensify, with a 50% increase in flood exposure for Florida residents by 2050 (Wing et al., 2021). The Atlantic and Gulf coasts have higher land subsidence rates than the Pacific coast which further exacerbates the relative SLR (Ohenhen et al., 2024).

1.3. Urban Coastal Flood Risk

Urban areas are at higher risk of experiencing flood impacts stemming from the spatial concentration of people, economic assets, and infrastructure (Skidmore and Lim, 2020). Due to the complex and interconnected nature of the built and natural urban systems, they provide unique

environments for the exploration of people's responses to coastal flooding and considerations toward relocation (Bukvic and Barnett, 2023). Moreover, the total urban area that may be subjected to SLR inundation has risen six-fold in the 20th century and is predicted to double during the 21st century (Moel et al., 2011). Urban flooding in the US has been increasing due to extensive suburban development resulting in greater flood flows into urban areas, inadequate infrastructure in older neighborhoods, poor maintenance of existing drainage systems, and increasing occurrences of intense rainfall (Rainey et al., 2021). Similarly, frequent flooding has been affecting critical infrastructure such as transportation (Jacobs et al., 2018), increasing the influx of saltwater into estuaries and adjacent groundwater aquifers (EPA, 2022), and impeding stormwater drainage (Rosenzweig et al., 2018).

Furthermore, the heavily populated coastal regions of the US Gulf and Atlantic coasts have been devastated by hurricanes in recent years, including Hurricane Irma (2017), Hurricane Harvey (2017), Hurricane Sandy (2012), and Hurricane Katrina (2005) (Castrucci and Tahvildari, 2018). In 2012, Hurricane Sandy struck the East Coast, resulting in over \$60 billion in total economic damage (de Moel et al., 2013) with approximately \$19 billion in damages in New York City and \$29 billion in New Jersey (Letzter, 2016). This historic cyclone affected the coastal communities by washing away roads in North Carolina's Outer Banks (Hoffman and Bryan, 2013), causing a blackout to about 5.5 million homes in the Northeast and Middle Atlantic regions, and flooding the New York subway system (Baker et al., 2012). Similarly, cities such as Charleston, SC, have been experiencing high tide events, accelerated SLR, and storm surge flooding, with Charleston Harbor experiencing 60 days of nuisance flooding annually from 2015 to 2020 (Cains, 2021). According to Sadler et al. (2017), under an intermediate scenario, it was estimated that about 10%

of the major transportation infrastructures at Norfolk and Virginia Beach will be regularly inundated with tides reaching 2.1 m above the base level established by NAVD88 by the year 2100.

1.4. Coastal Flooding Adaptation Strategies

The International Governmental Panel on Climate Change (IPCC) acknowledges three main strategies to combat coastal flooding: protection of the built environment using engineering approaches, accommodation by flood-proofing and early warning systems, and relocation from high-risk areas (Oppenheimer et al., 2019). However, these strategies are often expensive and challenging to implement due to the existing regulatory and political climate (Mach et al., 2019). According to the Financial District and Seaport Climate Resilience Master Plan, 2021, New York City has invested \$110 million to combat tidal flooding and SLR in the low-lying South Street Seaport neighborhood by raising the shoreline. While several mitigation projects have been planned or are currently in progress nationwide, funding for these initiatives is limited (FEMA, 2022). Because of SLR acceleration, accommodation, protection, and advancement measures, such as building seawalls and investing in beach nourishment or dune restoration are often ineffective in the long term (Lincke and Hinkel, 2018). Accommodation measures also require continued maintenance, can adversely impact the environment, and encourage development in high-risk areas (Hino et al., 2017). Similarly, investments in protective measures such as seawalls have short-term benefits and may eventually lead to the loss of beachfront due to SLR-driven erosion and property damage (Kousky, 2014). These limitations may leave coastal relocation as the most viable option for some high-risk areas with a combination of social and physical factors that might limit other adaptation options (Magnan et al., 2022).

Hauer et al. (2016) estimated that approximately 13.1 million individuals in the US could be at risk of relocating due to a sea level rise of 1.8 meters by 2100. Even though practitioners' disaster management and planning officials view relocation as an effective flood risk reduction strategy (Bukvic and Harrald, 2019), many localities instead opt for in situ hazard mitigation and adaptation approaches due to economic, public, and political pressures (Bukvic, 2015). Local adoption of relocation is closely related to socioeconomic, environmental, and political considerations, as well as government policies that incentivize or impede mobility (Hauer et al., 2020). In the US, relocation efforts are generally pursued in response to major disasters rather than proactively before a disaster occurs (USGCRP, 2023), even though this latter approach might minimize the relocation adverse outcomes.

The residents' willingness to relocate depends on sociodemographic factors such as age, flood exposure, expectations of future flooding (Bukvic et al., 2015), and place attachment (Anacio et al., 2016). According to Bott et al. (2019), people living in marginalized urban communities have a stronger sense of place attachment, suggesting that using a top-down approach to relocation planning without the residents' participation can cause social disputes and maladaptation. The mobility from vulnerable coastal regions is also affected by people's willingness to consider alternatives such as buyouts and rent-back (Hotard and Ross, 2023; Perry, 2022). For example, declining property value might compel residents to remain in flood-prone areas until a severe storm or flood event forces their displacement (de Vries and Fraser, 2012). A better understanding of the willingness to relocate, including people's preferences for a new destination, housing type, and employment needs, can minimize negative effects on the workforce, local revenues, and economic continuity (Bukvic and Barnett, 2023). Even though insights into individual willingness to

participate in a home buyout are important, previous research has focused on post-disaster relocation or home buyouts separately (Greer et al., 2019). Additionally, understanding how public perceptions of home buyouts are aligned with perceptions of relocation can indicate how this policy tool can be implemented by local governments to support coastal mobility.

1.5. Relocation Drivers

Many studies have explored post-disaster resettlement and reconstruction (Jha, 2009; Bang and Few, 2012; Ismail et al., 2014; Cuaton, 2019; Rohland, 2015), but there is a paucity of research on drivers of willingness to relocate (Mayer et al., 2020). The studies which have explored people's willingness to relocate are mainly case studies focused on a single location (Marino, 2012; Simms, 2021; Colten et al., 2018; Fussell et al., 2014; Moore and Acker, 2018) or single drivers like specific flood events (Oduola, 2020; Pinter, 2021; Marino, 2018), political factors (Gibbs, 2016), place attachment (Agyeman et al., 2009; Hanna et al., 2022; Maldonado et al., 2013; Bukvic et al., 2022), and buyouts (Keeler et al., 2022; Henderson, 2018; Perry, 2022). While adaptation strategies for protecting and accommodating individual households and communities are well established, those addressing relocation are still elusive and do not provide clear guidelines for implementing equitable relocation (Hauer et al., 2020). The relationship between mobility patterns and the spatial distribution of the perceptions that drive residents to relocate is often neglected, resulting in erroneous inferences about housing needs (Hu and Nejat, 2020) necessary for policymaking. Understanding the factors influencing willingness to relocate is also crucial for predicting population movements in response to future coastal changes. Such projections would allow strategic consideration of areas requiring expansion to accommodate displaced individuals, thereby facilitating more effective population assimilation. They would also help policymakers

anticipate and address the social and economic costs of relocation, overall improving relocation outcomes (Duijndam et al., 2022).

1.6. Subjective versus Objective Relocation Drivers

Furthermore, it is unclear if the concerns driving willingness to relocate align with the actual conditions residents face in at-risk areas, potentially indicating a higher risk of out-migration. This understanding of public perceptions of risk is gaining recognition as a crucial element in the decision-making process of natural hazard management due to several factors (Peacock et al., 2004). For instance, in the United States, policymaking is significantly influenced by public opinion, formed by individual and community heuristics that shape diverse worldviews (Layzer, 2012). The role of risk perception in risk awareness and the acceptance of risk reduction measures is a common theme in all risk-related research (Lupton, 1999; Slovic, 2000). Public acceptance of new policies may be limited when the perceived risk of the positive and negative implications does not align with the actual risk, as seen in cases where the public downplays the objective SLR risks based on past policies that didn't account for them (McGuire, 2015). Similarly, the misalignment in the perceived and objective predictors of relocation might lead to either underestimation or overestimation of housing needs and services needed to support anticipated coastal mobility.

Given that the housing market serves as a significant foundation for the economic system, the ability to simulate impacts on property values could aid in uncovering the actual risk of future climate change for financial institutions (de Waard, 2015). A flood risk perception from coastal counties in Georgia, North Carolina, and Maryland reveals that objective risk metrics influence perceived flood probabilities, but this influence is most observable when the risk metric is widely publicized (Turner and Landry, 2023). This highlights the importance of information campaigns

and outreach to shape public perceptions of flood risk. According to McGuire (2014), the government's policy stance on risk affects how information is perceived and acted upon. If policies favor risk discounting, it is more likely that the risk information will be disregarded. On the other hand, policies promoting risk integration, such as higher insurance premiums, help to align people's perceived and actual risks, making individuals more likely to understand and respond appropriately to the risks they face.

1.7. Problem Statement

About 40% of the US population resides in coastal areas, with a population that is five times denser in the coastal counties than the US average (NOAA, 2014). The rapid urbanization and economic development along the coastline of the United States have increased the vulnerability of the coastal communities to flood hazards (Sadiq et al., 2019). The East Coast of the United States has densely populated urban areas exposed to increasing intensity and frequency of flooding events predicted in the coming years (Ezer and Atkinson, 2014; Ezer and Atkinson, 2017; NOAA, 2021; Wing et al., 2021). This heightened threat calls for an effective disaster management strategy to reduce the impacts of the hazards by minimizing economic, social, and environmental loss. Even though relocation is the least preferred policy in disaster management (ADB, 1998; Jha, 2009; Iuchi and Mutter, 2020), with the increasing occurrences of flooding events in coastal communities, a well-planned relocation is essential to reduce the impacts of future disaster hazards (Arnall, 2013).

However, urban relocation is a deeply complex process that involves a detailed understanding of the social, economic, and environmental components. Understanding the factors that drive willingness to relocate is essential for forecasting population shifts due to future coastal changes.

These predictions enable strategic planning for expanding areas to house displaced individuals, promoting more efficient population integration. Additionally, they assist policymakers in anticipating and mitigating the social and economic impacts of relocation, ultimately enhancing the success of relocation efforts (Duijndam et al., 2022). Thus, it is important to identify the areas with a heightened willingness to relocate among the residents and the drivers influencing their decisions. This allows policymakers to tailor relocation strategies to specific community needs and preferences, ultimately increasing the likelihood of successful implementation and community acceptance.

Research Objective and Questions

This research addresses the aforementioned knowledge gap by evaluating relocation risk among urban coastal residents in a defined set of geographic study locations of higher willingness to relocate among survey respondents. Namely, it addresses the following questions:

RQ1: What factors drive relocation decision-making in the geographic urban study locations with high support for relocation across the East Coast?

RQ2: Are these factors constant across the geographic regions that experience different types of flood hazards?

RQ3: To what extent are the key factors driving respondents' willingness to relocate already present in the selected study locations?

Chapter 2: Manuscript

Key Drivers of Coastal Relocation in Spatial Clusters Along the U.S. East Coast

Abstract

Coastal flooding has been increasing in frequency and severity across the US East Coast, adversely impacting the human population. Preferred adaptation strategies, such as protection and accommodation, may prove insufficient under current climate change scenarios and projected future sea level rise, prompting the coastal population to consider relocation a more efficient disaster risk reduction strategy. This study focuses on the flood-prone urban areas along the US East Coast where residents are more willing to relocate due to coastal flooding. Using survey data, it evaluates the flood experiences, considerations toward relocation, and preferences for relocation destinations. The extent of top concerns influencing respondents' willingness to relocate, such as crime rate, buyout programs, access to critical services and amenities, and availability of comparable housing, were further explored as indirect relocation drivers.

Four geographic study locations with heightened relocation potential were identified across urban areas on the US East Coast. Relocation drivers such as crime and limited access to services and amenities are not significantly observed in these study locations. However, the absence of buyout programs and affordable housing options in nearby communities leaves low-income households trapped in high-risk zones, exacerbating socioeconomic disparities and increasing the disproportionate risk faced by marginalized populations.

The findings have important implications for policymakers, urban planners, and stakeholders in climate adaptation and disaster risk reduction efforts. They highlight the need for targeted

interventions to address socioeconomic vulnerabilities, promote equitable access to housing, and enhance the resilience of communities facing coastal hazards.

Keywords: Coastal flooding, relocation drivers, spatial clusters, East Coast

Introduction

The East Coast of the United States stands as one of the nation's most vulnerable regions, characterized by densely populated urban areas increasingly experiencing high tide flooding. Recent National Oceanic and Atmospheric Administration (NOAA) data reveals that 80% of tide gauge locations now exhibit accelerated flooding rates (NOAA, 2022). The US Army Corps of Engineers highlights that the North Atlantic shoreline is undergoing significant changes in response to rising sea levels, with historic erosion patterns projected to worsen (USACE, 2015). The low relief of the East Coast exacerbates its susceptibility to inundation and erosion, with minor tidal flooding surging along the coastline from the Gulf of Maine to Florida (Ezer and Atkinson, 2014). Additionally, projections indicate that hurricanes approaching the East Coast are likely to increase in intensity (Ting et al., 2019), while the warming Florida ocean current has accelerated sea level rise between Key West and Cape Hatteras, fostering conditions conducive to nuisance flooding (Domingues et al., 2018). In Florida alone, flood exposure is expected to escalate by 50% by 2050 (Wing et al., 2021).

Urban areas face amplified flood risks due to the concentration of human and economic assets within relatively small areas (Skidmore and Lim, 2020). The interconnected nature of urban systems provides a unique environment for examining responses to coastal flooding and relocation risk (Bukvic and Barnett, 2023). The 20th century saw a six-fold increase in the area susceptible

to sea level rise inundation, a figure expected to double in the 21st century (Moel et al., 2011). Factors such as extensive suburban development, inadequate infrastructure in older neighborhoods, poor maintenance of drainage systems, and more frequent intense rainfall have contributed to the rise in urban flooding (Gerald et al., 2018). These floods impact critical infrastructure, increase saline water influx into estuaries and groundwater, and reduce stormwater drainage capacity. Recent hurricanes, including Irma (2017), Harvey (2017), Sandy (2012), and Katrina (2005), have devastated the heavily populated Gulf and Atlantic coasts (Castrucci and Tahvildari, 2018). For instance, Hurricane Sandy caused over \$60 billion in damages, significantly affecting New York City and New Jersey (de Moel et al., 2013; Letzter, 2016), and its impact included washed-away roads, blackouts, and flooding of the New York subway system (Hoffman and Bryan, 2013; Baker et al., 2012). Charleston, SC, has recorded 60 days of nuisance flooding annually from 2015 to 2020 due to high tide events and storm surges (Cains, 2021). By 2100, it is estimated that about 10% of Norfolk and Virginia Beach's major transportation infrastructure will be regularly inundated under an intermediate sea level rise scenario (Sadler et al., 2017).

To address coastal flooding, the International Governmental Panel on Climate Change (IPCC) recommends three primary strategies: engineering approaches for protection, flood-proofing and early warning systems for accommodation, and relocation (Oppenheimer et al., 2019). For instance, New York City has invested \$110 million to raise the shoreline in the South Street Seaport neighborhood to combat flooding (Financial District and Seaport Climate Resilience Master Plan, 2021). Despite numerous planned and ongoing mitigation projects, funding remains limited (FEMA, 2022). The rapid rise in sea level often renders accommodation measures ineffective (Lincke and Hinkel, 2018). While protective measures such as seawalls provide short-

term benefits, they may eventually lead to beach loss and increased erosion on adjacent properties (Kousky, 2014). Similarly, accommodation measures can entail high maintenance costs, potential environmental harm, and encourage development in hazardous areas (Hino et al., 2017).

Consequently, coastal relocation is increasingly viewed as a viable option in light of current and projected sea level rise. The National Climate Assessment (NCA, 2018) estimates that over 13 million people may need to relocate due to rising sea levels. Although relocation is considered an effective risk reduction strategy by disaster management professionals (Bukvic and Harrald, 2019), many localities opt for in situ hazard mitigation despite frequent flood exposure (Bukvic, 2015). Relocation decisions are influenced by various socioeconomic, political, and environmental factors, as well as government policies and incentives (Hauer et al., 2020). Residents' willingness to relocate depends on demographic factors, flood exposure, and expectations of future flooding (Bukvic et al., 2015). For instance, post-Hurricane Andrew studies indicate that low-income households often move into heavily damaged areas, middle-income households relocate to reduce risk, and wealthy households with better access to insurance tend to stay (Smith et al., 2006).

Place attachment also significantly influences the willingness to remain in high-risk areas (Anacio et al., 2016). Residents in marginalized urban communities often exhibit strong place attachments, making top-down relocation planning challenging without considering residents' perceptions (Bott et al., 2019). The motivation to consider alternatives such as buyouts and rent-back for asset risk management also plays a role in relocation decisions (Perry, 2022). Declining property values may compel residents to stay in flood-prone areas until a severe event forces relocation (de Vries and Fraser, 2012). Understanding the decision-making process, including preferences for new destinations and housing and employment needs, is crucial for minimizing negative impacts on the

workforce, local revenues, and the economy (Bukvic and Barnett, 2023). The distinction between perceived and actual risks is also vital in the willingness to relocate. Objective predictors, such as housing values and flooding events, differ from subjective predictors based on individual perceptions (Rejda and McNamara, 2021). Public perceptions of risk significantly influence decision-making and policy acceptance (Peacock et al., 2004). Misinformation and misperceptions can hinder preparedness and increase disaster vulnerability (Landry & Turner, 2020). Aligning perceived and actual risks is essential for effective policy implementation and future sustainability proposals (McGuire, 2014).

While extensive research exists on post-disaster resettlement and reconstruction, studies on the drivers influencing willingness to relocate are scarce (Mayer et al., 2020). Effective policy proposals must consider public sentiment and avoid relying solely on objective risk assessments (McGuire, 2015). Understanding both actual and perceived risk perceptions is crucial for successful policy implementation. Adaptation policies for protection and accommodation are well established, but those for relocation remain vague and lack clear guidelines (Hauer et al., 2020). Addressing gaps in understanding the geographic distribution of flood-induced relocation study locations and preferred destinations is vital for accurate housing needs assessments and effective policymaking.

Using survey data described below, this study first identifies geographic study locations of high willingness to relocate and their reported flood exposures and spatial variability, reasons for relocation, and preferences for relocation destinations. Then, it determines whether the key concerns driving respondents' willingness to relocate correspond to the actual conditions to identify the relocation likelihood. Understanding direct and indirect circumstances predictive of

the willingness to relocate will be critical to minimizing the socioeconomic and psychological cost of flood-driven displacement and shaping an equitable relocation focused on supporting services and housing needs of relocating populations. It will also enable local governments to understand compounding factors that could influence the willingness to move among coastal populations and think more critically about their role in managing the relocation process through land use changes and regulatory interventions.

4. Data and Methods

4.1. Survey

A survey was administered in nine coastal states facing the Atlantic Ocean: New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida (**Figure 1a**). These states have been facing frequent chronic and episodic coastal flooding, including the number of major coastal disasters declared in the 20-year period from 2003-2023 (**Figure 1b**). The survey data were collected from 1,450 respondents living in flood-prone urban areas from May to June 2021 using the Qualtrics online survey platform. A detailed description is available in Bukvic and Barnett (2023). Survey respondents were selected using purposive non-probability sampling, considering that the study area was defined to include only coastal locations with substantial flood risk that may result in displacement. The survey was administered and collected at the ZIP code level within metropolitan statistical areas based on their flood exposure. FEMA's National Flood Hazard Layer, identifying surface areas with at least a 26% chance of flooding over the life of a 30-year mortgage was used to spatially define the overlap of high-risk flood zones with each zip code. ZIP codes with less than 25% overlap were excluded, leading to 177 unique zip codes that served as the survey recruitment areas.

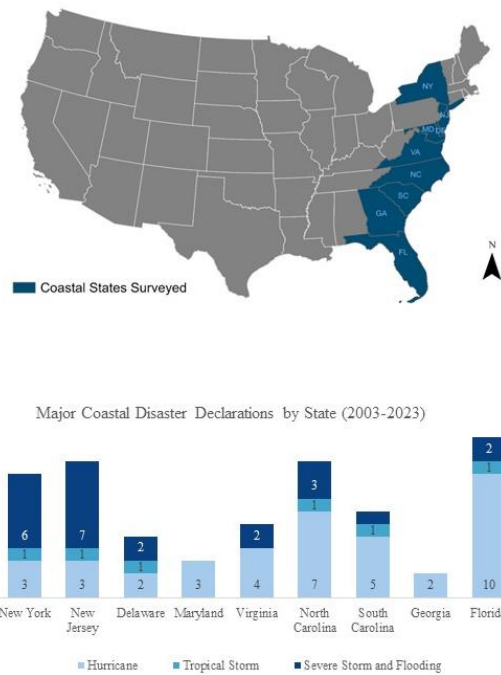


Figure 1. The nine surveyed coastal states (a), and the major coastal disaster declarations by state, 2003-2023 (b) (FEMA).

The survey consisted of 20 questions focused on socioeconomic characteristics, place attachment, willingness to relocate, personal risk and vulnerability to flooding, preferences for relocation destinations, and experiences with flooding. The survey's conceptual framing was based on the push and pull migration theory (Lee, 1996) which states that people are motivated to migrate or relocate due to a combination of "push" factors, which compel them to leave their current location, and "pull" factors, which attract them to a new destination. For example, the push factors included exposure and experience with flooding and concerns with flood impacts, while the pull factors included place attachment determinants and desirable community features of the relocation destinations.

4.2. Cluster Analysis

The next step identified the zip codes within the study area where 75% or more respondents would be willing to relocate. The final subsample consisted of 24 zip codes, with more than 75% of respondents saying yes to relocation (n=114) (**Figure 2**). Descriptive statistics were generated for the socio-demographic responses, responses on flood exposure, and sense of place for the final subsample of 114 respondents. The top four considerations driving the respondent's willingness to relocate within the study locations were sourced from the question assessing factors influencing

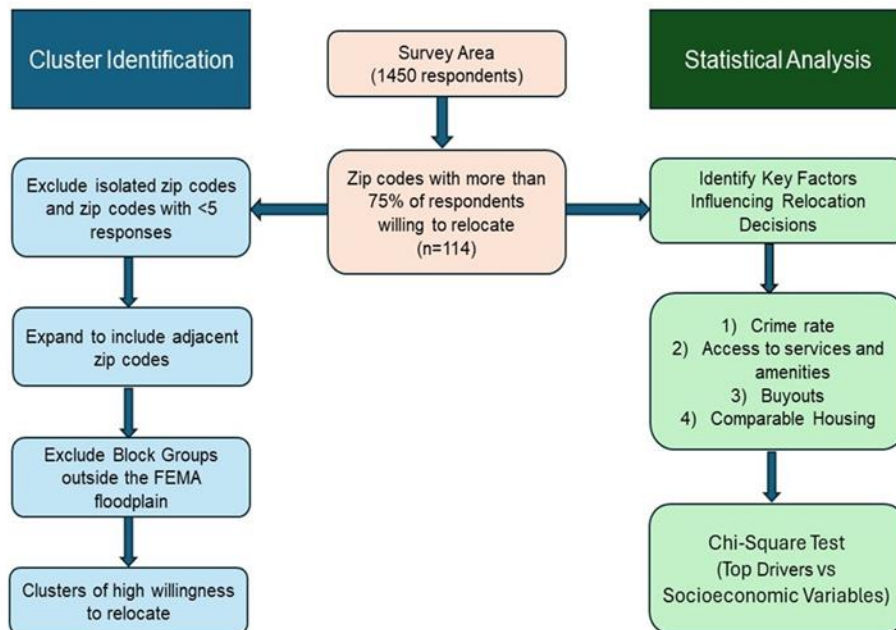


Figure 2. An overview of cluster identification method and statistical analysis.

respondents' consideration of permanent relocation from their community to a less flood-prone location. The responses were measured on a five-point Likert scale (strongly agree to strongly disagree), highlighting increasing crime as the most frequently reported driver of relocation willingness at 63%. Additionally, the limited access to critical services and amenities, the prospect

of financial compensation or buyout, and the availability of comparable housing in a less flood-prone community were identified as reasons to relocate by 54% of respondents in this subsample. The zip codes selected from the cluster analysis were isolated, and fewer than five survey responses were excluded. This approach resulted in four study locations in New York, Georgia, Florida, and Virginia. These study locations served as potential indicators of areas more supportive of relocation. They were expanded to include adjacent ZIP codes with similar typology (e.g., flood exposure and community characteristics such as population density). The percentage of respondents willing to relocate was examined to validate the consistency of relocation responses adjacent to the identified cluster. Notably, the examined ZIP codes exhibited more than 50% of the respondents willing to relocate from the area. This observation underscores the necessity of broadening the analysis to include nearby areas and conducting further investigations at the community and municipal levels. Finally, the block groups entirely within the ZIP codes were considered for further analysis. In our study, study locations identified from the survey data served primarily as an indicator or seed, guiding us to identify locations that warranted research in coastal relocation.

4.3. Statistical Analysis

A Chi-Square test of independence was employed in the final subsample of 114 respondents to analyze the association between sociodemographic characteristics and relocation drivers. To meet the requirements of the Chi-Squared test of independence, we merged categories if more than 20% of expected counts were <5 . Bonferroni correction was used as the multiplicity adjustment method to control the probability of Type I errors. The association between the variables was then checked based on the adjusted p-values. R studio V2.3.1 was used for statistical analysis.

4.4. Geospatial analysis

The concerns that emerged as critical determinants of willingness to relocate were an increase in crime, access to critical facilities and amenities, availability of buyout programs, and offer of comparable housing elsewhere. The analysis exploring these aspects was conducted at the block group (BG) level to facilitate a more nuanced understanding of the granular place-based factors influencing willingness to relocate. Additionally, analyzing data at the BG level allows for better alignment with existing demographic and socioeconomic indicators, enhancing the transferability and policy relevance of the analysis. To maintain consistency, we excluded block groups that did not intersect with FEMA 100-year floodplain zones (A, AO, AH, AR, A1–A30, AE, A99, V, VE, and V1–V30), focusing the analysis solely on areas with similar flooding experiences.

4.5. Crime Rate

To assess the crime trends within the study area, the FBI's Uniform Crime Report (UCR) Report (UCR) served as our primary dataset. UCR documents crime incidents for the entirety of the United States (David et al., 2014) and includes data from more than 18,000 city, university, college, county, state, tribal, and federal law enforcement agencies (UCR, 2024). Given that our study area spans the US East Coast urban regions, the UCR dataset was well-suited for this analysis. Crime Data Explorer (CDE), an interactive online tool and the digital interface of the UCR program, facilitated the retrieval of violent crime and property crime from multiple police departments operating within our counties of interest, ranging from 1985 to 2019. The data for our analysis was limited to 2019 to ensure consistency due to the unavailability of the data for 2020, 2021, and 2022 in several police departments within our target counties. A time series analysis was conducted on the historical dataset to comprehend the crime rate trend within the study area.

4.6. Access to Services and Amenities

The National Flood Hazard Layer (NHFL) datasets provided by the Federal Emergency Management System (FEMA) were used to delineate the areas of high flood risk. The NHFL provides the most accurate digital spatial dataset depicting the location and boundaries of Special Flood Hazard Areas (SFHAs), along with the corresponding floodwater surface elevations (Crowell et al., 2013). SFHA represents the high-risk flood zones (A, AO, AH, AR, A1–A30, AE, A99, V, VE, and V1–V30) that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year and are also referred to as the 100-year flood or base flood (FEMA, 2020). The 100-year floodplain is the traditional metric in the United States used to determine the likelihood of an area being inundated by flooding (Blessing et al., 2017; Highfield et al., 2013) and has been utilized by several studies in mapping flood vulnerability (Tate et al., 2021; Qiang, 2019; Lorie et al., 2018; Thakali et al., 2017; Qiang et al., 2017).

The services and amenities data were obtained from OpenStreetMap using QGIS and included arts centers, banks, bicycle parking, bus stations, cafes, car rentals, car wash facilities, casinos, childcare centers, cinemas, colleges, community centers, conference centers, courthouses, event venues, fast food establishments, fire stations, hospitals, libraries, pharmacies, police stations, restaurants, supermarkets, theaters, and veterinary services from the OpenStreetMap database. The services and amenities that were within the SFHA polygon boundaries were spatially analyzed by overlaying the SFHA polygons onto the OSM services and amenities dataset. The percentage of services and amenities that could potentially become inaccessible due to flooding was then calculated for each of the relocation study locations.

4.7. Buyouts

The data for allocated buyout programs in the study area were obtained from the Hazard Mitigation Grant Program (HMGP), an open government database maintained by FEMA (FEMA, 2024). Among the five Hazard Mitigation Assistance Programs provided by FEMA, HMGP serves as the primary avenue for financing property acquisition and relocation from a floodplain (Bukvic & Borate, 2020). Since its creation in the 1980s, this program has been increasingly used for home buyouts, particularly following legislative revisions prompted by the significant flooding of the Mississippi and Missouri rivers in 1993, emphasizing the importance of preventive measures in flood risk mitigation (Pinter, 2005). The summary file of the HMGP database contains information about the counties associated with the project, disaster declaration date, incident type, project title, project type, description, county, status, sub-grantee, project amount, obligatory federal share, and cost share percentage from 1996-2024. The information on the acquisition and relocation projects was filtered from the database.

Given that relocation assistance and willingness are typically administered by the state and the local government, the most granular level of information was available at the county level. Therefore, we looked into the acquisition/relocation projects in the counties where the study locations of relocation were located, i.e., New York County and Kings County in New York, Norfolk and Portsmouth City in Virginia, Chatham County in Georgia, and Broward and Dade County in Miami, Florida. In addition to the HMGP, our analysis encompassed other buyout programs, such as Community Development Block Grant Disaster Recovery (CDBG-DR) and NYC Build it Back, initiated at the state or local level. This comprehensive approach ensures a thorough understanding of the range of buyout initiatives within our area of interest.

4.8. Comparable Housing

The data on the housing units and costs is provided by the US Census Bureau at the BG level. The ACS records estimated selling prices for occupied housing units and vacant housing units under “value” and “price asked” tables respectively. The value of the occupied units in the study area was compared with the vacant-for-sale-only and sold households in the surrounding areas to identify if there are any comparable housing units nearby within the same county that can accommodate the relocating population.

5. Results

5.1. Descriptive Statistics

5.1.1. Socioeconomic Factors

The respondents’ socioeconomic profiles within the selected study locations revealed distinct patterns (**Figure 3**). Most participants (36%) were in the younger age group 18-29, followed by

19% in the 30-39 age bracket, 17% in the 50-59 age group, 15% in 14-49 and 13% in the 60 and over. Regarding race, the majority of respondents identified as white (49%), followed by Black/African American (28%) and Hispanic/Latino/Spanish (14%), with the remaining 10% falling into other racial categories. Half of respondents held a bachelor's degree or higher (50%), while 30% completed high school as their highest level of education. Additionally, 16% held a certificate or associate degree, and 1.75% had completed less than high school. Regarding employment status, 50% of respondents were employed full-time, while 23% worked part-time. Further, 10% were unemployed, 5% were stay-at-home parents, and 6% were retired. Income distribution revealed that 24% of respondents fell into the upper-income bracket (\$100,000 and above). In comparison, 32% belonged to the middle-income category (\$50,000 to \$99,999), and the remaining 44.74% fell into the lower-income bracket (less than \$50,000).

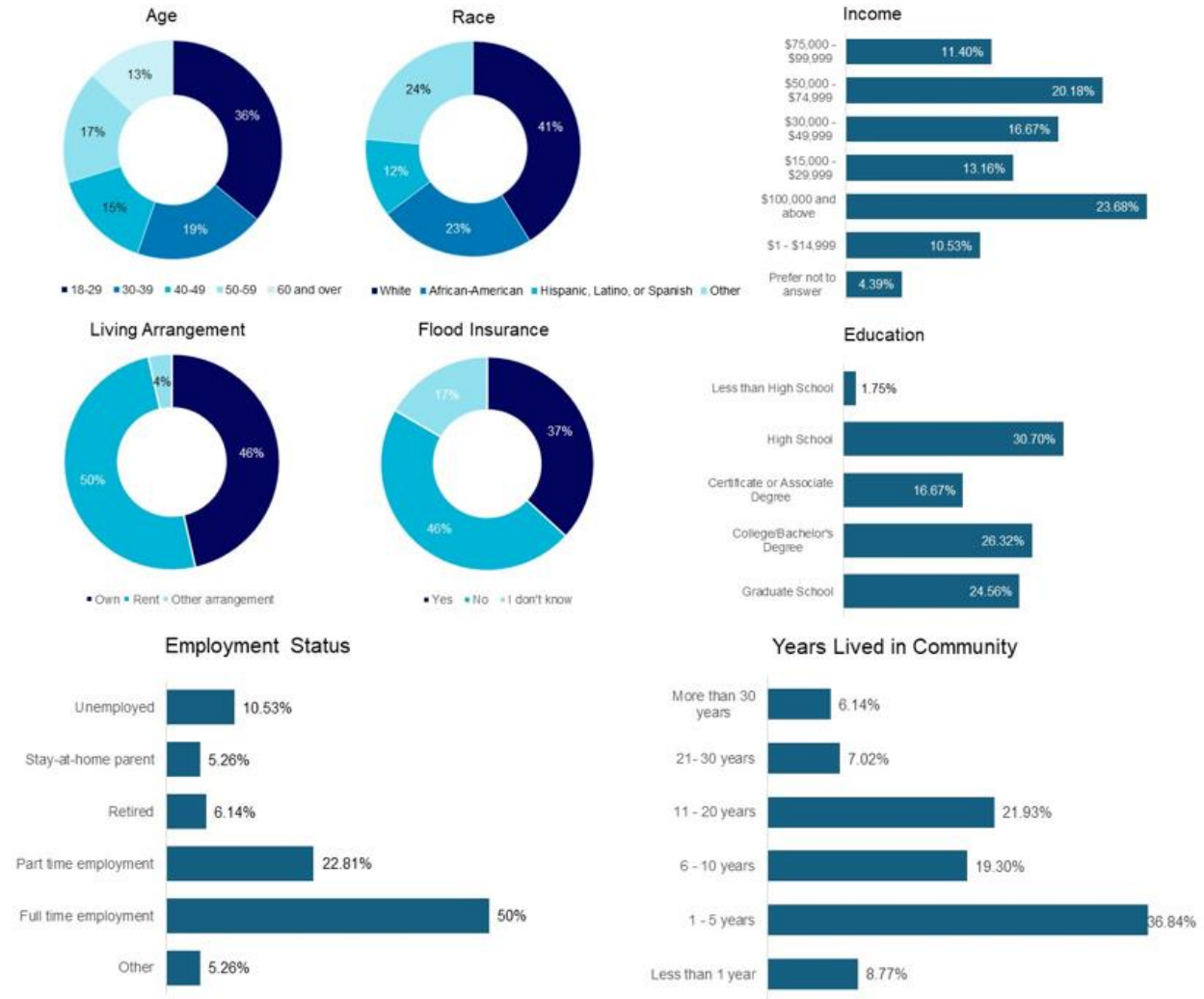


Figure 3. Descriptive statistics of the socioeconomic factors (age, race, income, living arrangement, flood insurance, income and education, employment status, and number of years lived in the current home).

As for housing, half of the respondents rented their living spaces, while 46% owned their homes, and the remaining 4% had alternative living arrangements. The length of residence in the community varied, with 46 % of the respondents residing in their communities for the past five years, 41% from 6-20 years, and 13% living there for longer than 20 years. These results were

consistent with the total sample pool of 1,450 respondents along the US East Coast. The most notable disparities between the subsample with high relocation potential and the entire sample of 1,450 data points emerged in National Flood Insurance Policy (NFIP) enrollment. Across the original sample, a majority (53%) reported ownership of the National Flood Insurance Policy (NFIP), with 32% uncertain about enrollment and 15.10% lacking NFIP coverage. However, within the subsample, most respondents (46%) did not have NFIP policy, 37% reported NFIP ownership, and 17% were uncertain about enrollment.

5.1.2. Place Attachment

The survey also explored the place attachment of the respondents, namely what is important to them about living in their community, what makes them feel attached to their community, and how they respond to the problems in their community. The first two questions assessed features shaping the place attachment, such as features such as the presence of amenities nearby, proximity of friends and family, vicinity of the oceanfront, the layout of the community, the low crime rates, and fewer hazards and disaster events in the past in the community. In the strongly agree and agree category, the top factors important to respondents about living in the community were having friends in the community (78%), proximity to the beach (75%), and amenities close by (70%) (Figure 4). Even though the respondents in this subsample will consider permanent relocation if the flooding becomes more frequent, they still prefer living near the beach. Similarly, attending church and local organizations (32%) and having community support in time of need (50%) were the least important options among the respondents.

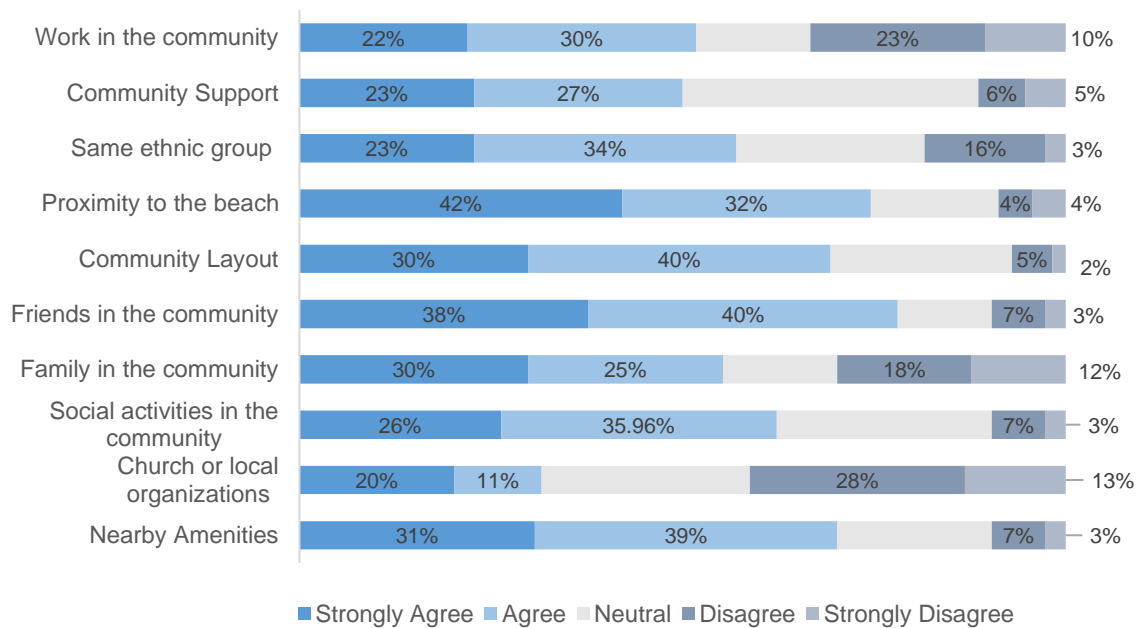


Figure 4. Likert scale responses measuring what is important to respondents about living in their community.

The second question on place attachment focuses on a broader set of community-level features (**Figure 5**). The top aspects contributing to the stronger sense of place were desirable features such as social and recreational places (e.g., churches, playgrounds, libraries, shops, and restaurants) with 73% and nearby critical facilities (70%). The other important community features were plenty of open space such as parks, community gardens, and greenways (68%), amenities and gathering places (66%), fewer vacant or abandoned lots in the community (57%), presence of historical landmarks (57%), long-lasting traditions and history of the place (56.14%), low crime rates (50%), fewer experienced hazards and disaster events (48%), no new urban development (40%) and presence of undesirable features such as industry, airport, highways, wastewater treatment facilities, powerplant and landfills (40%). In response to a question on how respondents solve the problems in the community, 60% consider themselves self-sufficient, with only 23% relying on

the government and 11.4% on their friends and neighbors. The lowest percentage of the respondents relied on the Internet and media to solve their problems (4%) and would prefer to relocate instead of trying to solve the problems in their community (3%).

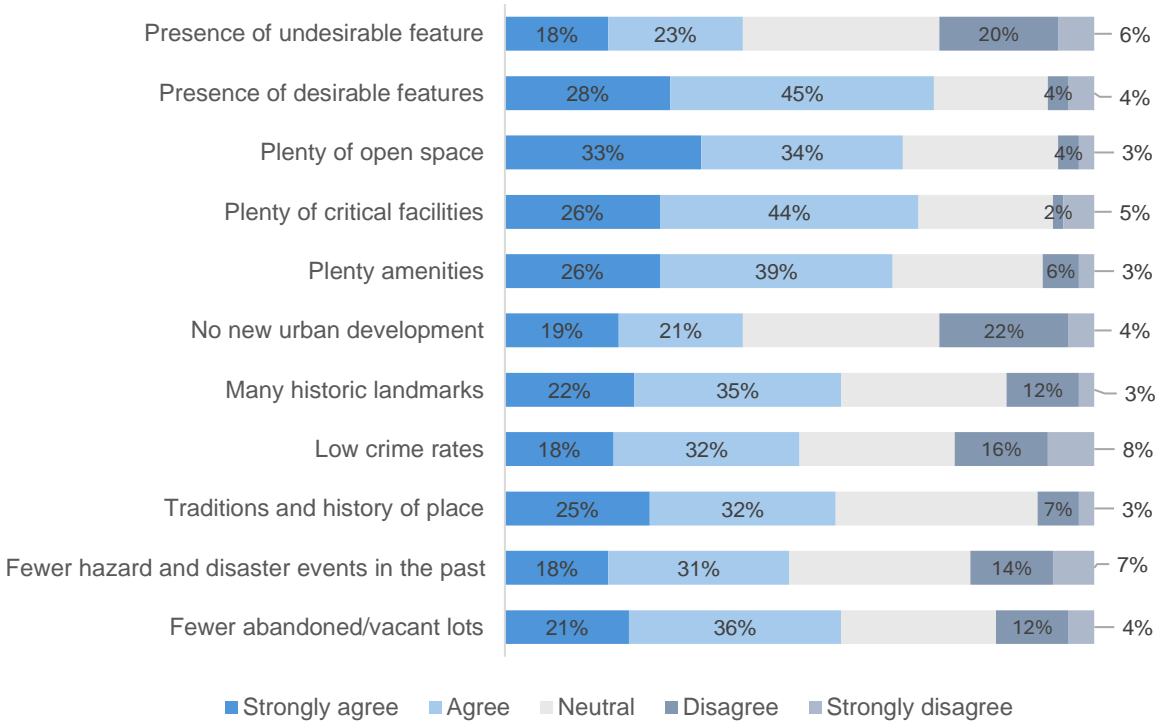


Figure 5. Likert scale responses measuring the community features that is important to respondents

5.1.3. Exposure

Most of the respondents in the study locations (42%) experienced rainfall or extreme rain events and 50% had experienced storm surges during storm events such as tropical storms, hurricanes, and nor’easters. The percentage of respondents who had experienced sunny days, nuisance, or tidal flooding or did not experience any flooding events was lower at 18%. A significant percentage of

the respondents rated their risk of flooding as medium (41%). Regarding the flood risk rating, 19% of the respondents rated their flood risk as extremely low, and 23% as low. 12% and 5% of the respondents considered themselves at high and extremely high risk of flooding, respectively. Further, 80% of the respondents experienced some impact due to flooding (**Figure 6**) with difficulty in commuting to work (46%) as the most experienced impact followed by damage to personal vehicles (32%). School delays and closures were experienced by 31% of the respondents, while 23% of the respondents experienced business delays and closures.

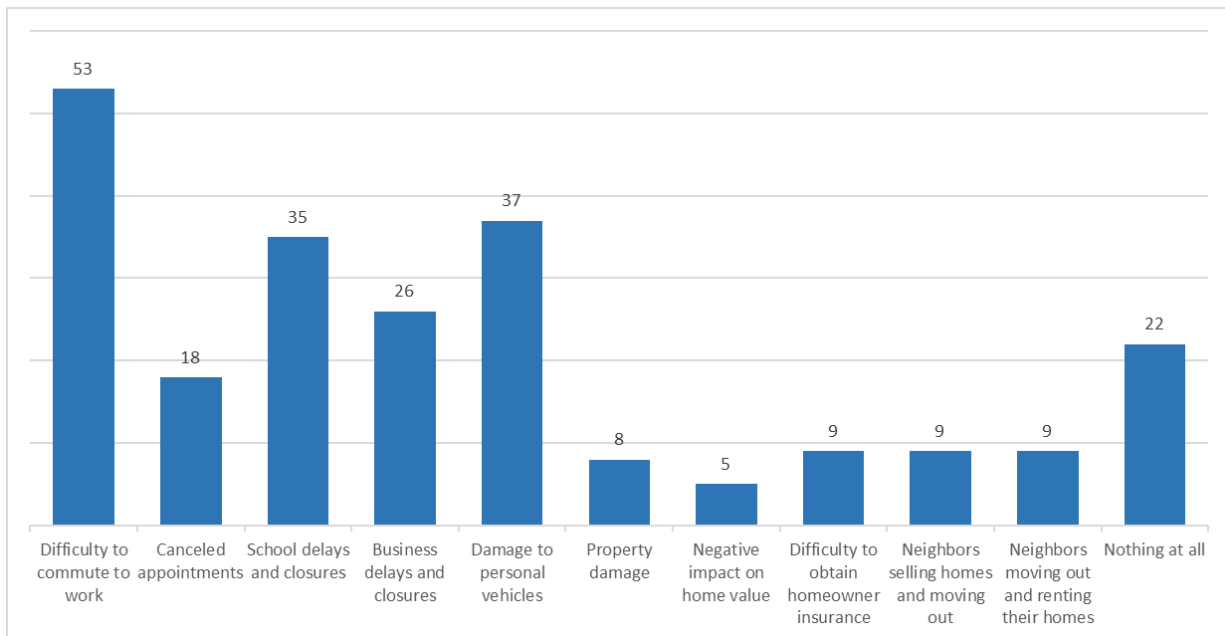


Figure 6. Flooding impacts experienced by respondents in the study locations with high willingness to relocate.

5.1.4. Relocation drivers and destination preferences

Next, the respondents were asked to rank reasons that would prompt them to consider permanently relocating from their community to a less flood-prone location (**Figure 7**). In the strongly agree

and agree categories, the top-ranked reason was worsened crime (63%), followed by access to amenities and services (54%), an offer of comparable housing in a similar community (54%), and availability of financial compensation or a buyout (54%).

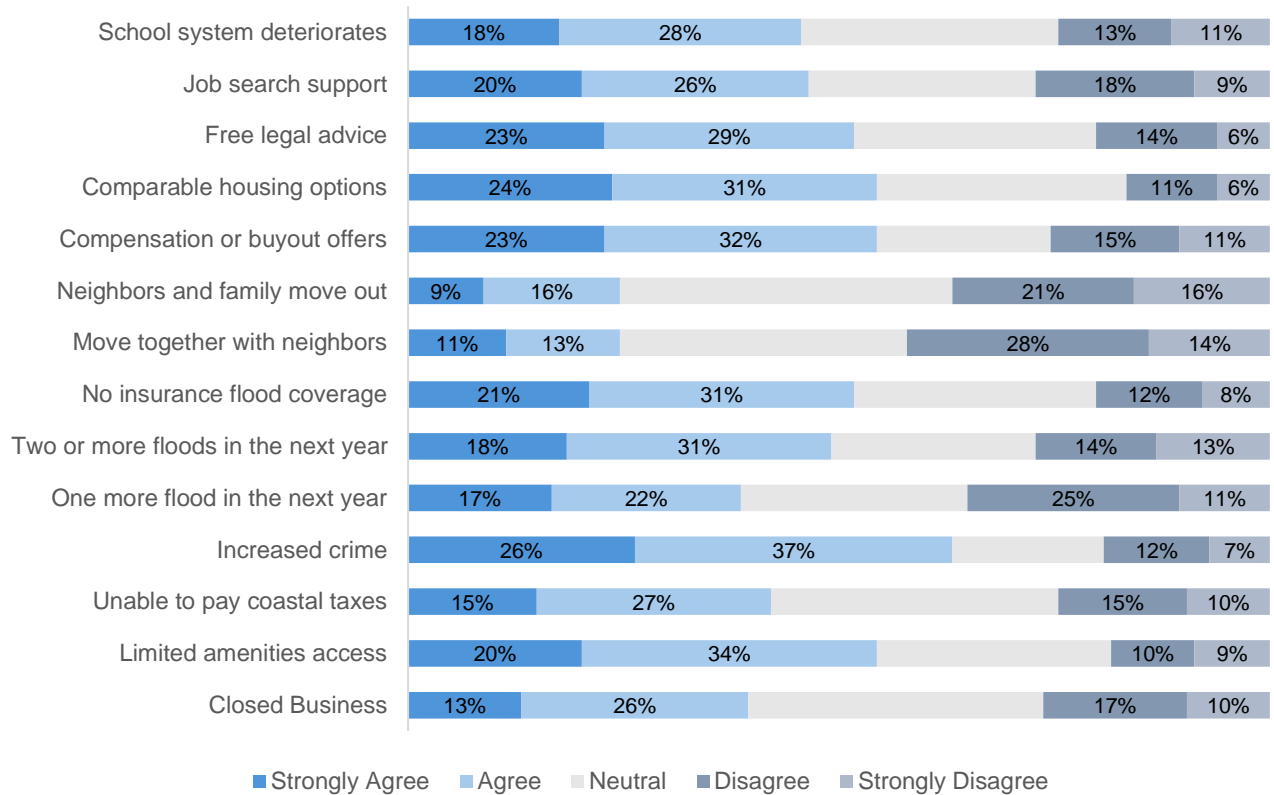


Figure 7. Likert scale responses measuring the relocation drivers

When asked about where they would prefer to move after relocation, a significant proportion of respondents would prefer to relocate locally (52%), specifically, within the same neighborhood but to a different residence (18%), within the same community but in a different neighborhood (16%), or within the same county (18%). Additionally, a considerable percentage indicated a desire

to remain within their current state (21%). In contrast, a smaller proportion (11%) preferred relocating to an entirely new state. When it comes to the community setting, the majority of the respondents (50%) did not want to change the type of their setting in relocation destination, with 33% of the respondents preferring to move from an urban to an urban area and 17% from a suburban to another suburban location. Only 5% of the respondents would prefer to move from suburban to rural, and 11% from urban to suburban. As for the reasons influencing their selection of relocation destination, 75% of the respondents would consider being in a safer and more socioeconomically stable community and 58% would consider being in a safer place with a lower risk of hazards (**Figure 8**).

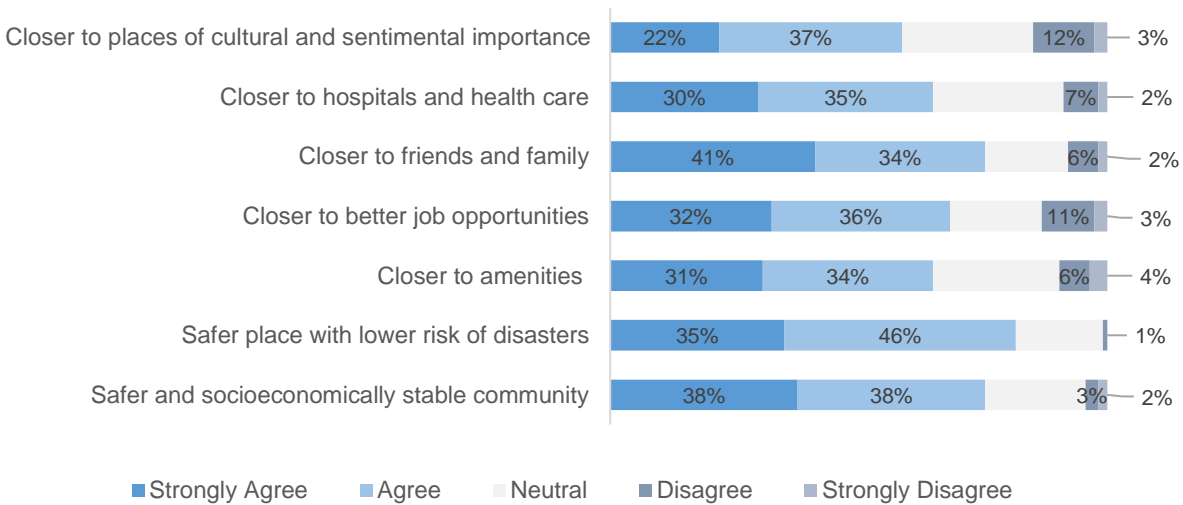


Figure 8. Likert scale measuring the reasons influencing the selection of relocation destinations

5.2. Statistical analysis

The Chi-Square test revealed few associations between socio-demographic factors and top drivers of relocation (**Table 1**). Age, race, education level, employment status, home ownership, and

number of years lived in the community were not significantly associated with the examined top four drivers of relocation ($p > 0.05$). Income was significantly associated with preference for financial compensation ($p < 0.01$) and comparable housing ($p < 0.05$), suggesting the income of the respondents affects their likelihood of relocating if they are provided with financial compensation or buyout and if there is comparable housing in similar communities. Similarly, home ownership is significantly associated with the availability of comparable housing indicating that whether a person rents or owns the property affects their willingness to relocate if provided with comparable housing. Finally, ownership of flood insurance was associated with the provision of financial compensation or buyout ($p < 0.05$), with the likelihood of flood insurance ownership influencing the willingness to relocate if the respondents are provided with financial buyouts. The mosaic plots of the contingency table for the dependent and independent variables are available in the Appendix (Figure A1).

Table 1. Chi-square tests between socioeconomic variables and top drivers of relocation.

	Crime increase	Limited access to services/amenities	Offer of financial compensation or buyout	Availability of comparable housing
Age	0.290	0.184	0.263	0.571
Race	0.316	0.978	0.626	0.945
Education level	0.965	0.995	0.108	0.143
Employment	0.506	0.747	0.264	0.731
Income	0.907	0.804	0.001**	0.046*
Home Ownership	0.793	0.725	0.059	0.021*
Years lived in the community	0.380	0.210	0.205	0.577

Flood Insurance	0.410	0.411	0.031*	0.319
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5.3. Crime

Based on the survey data, the increase in crime was identified as the key factor influencing people’s willingness to relocate permanently. Through a comprehensive historical time series analysis, we observed a consistent decrease in both violent and property crime reports across all identified relocation study locations (**Figure 9**). The trend line analysis offered valuable insights into the projected trajectory of overall crime rates, revealing a downward trend in reported incidents. Furthermore, the R-squared (R^2) values for the slopes of the trend lines provided additional quantitative validation of our findings. Specifically, the R^2 values for the identified study locations were as follows: New York and Kings County (0.703), Norfolk and Portsmouth (0.735), Chatham (0.628), and Broward and Miami-Dade County (0.8229).

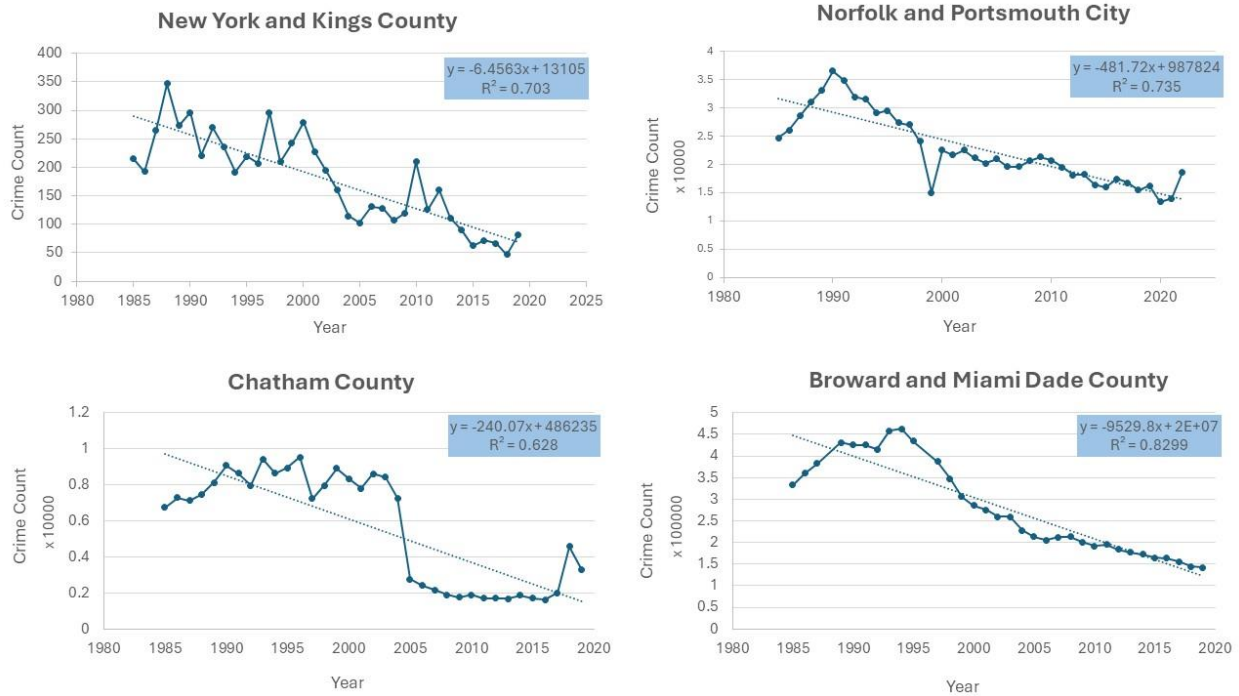


Figure 9. The crime reports in study locations of relocation between 1985-2019

5.4. Access to amenities and services

The survey revealed a strong inclination among respondents towards considering relocation to less flood-prone areas if flooding limits access to services and amenities. Geospatial analysis of study locations indicates the proportion of amenities situated within 100-year floodplain areas in the relocation study locations. Notably, Florida has the highest percentage of amenities at risk of inundation, with 62.50% falling within high-risk flood-prone zones (A, AO, AH, AR, A1–A30, AE, A99, V, VE, and V1–V30), followed by New York which also demonstrated a significant exposure, with 38.13% of services and amenities susceptible to inundation. Both Virginia and Georgia exhibited a lower risk of flood impact on services and amenities, with 26.44% and 22.35%, respectively. The services and amenities situated in the FEMA floodplains for each of the locations are shown in **Figure 9**.

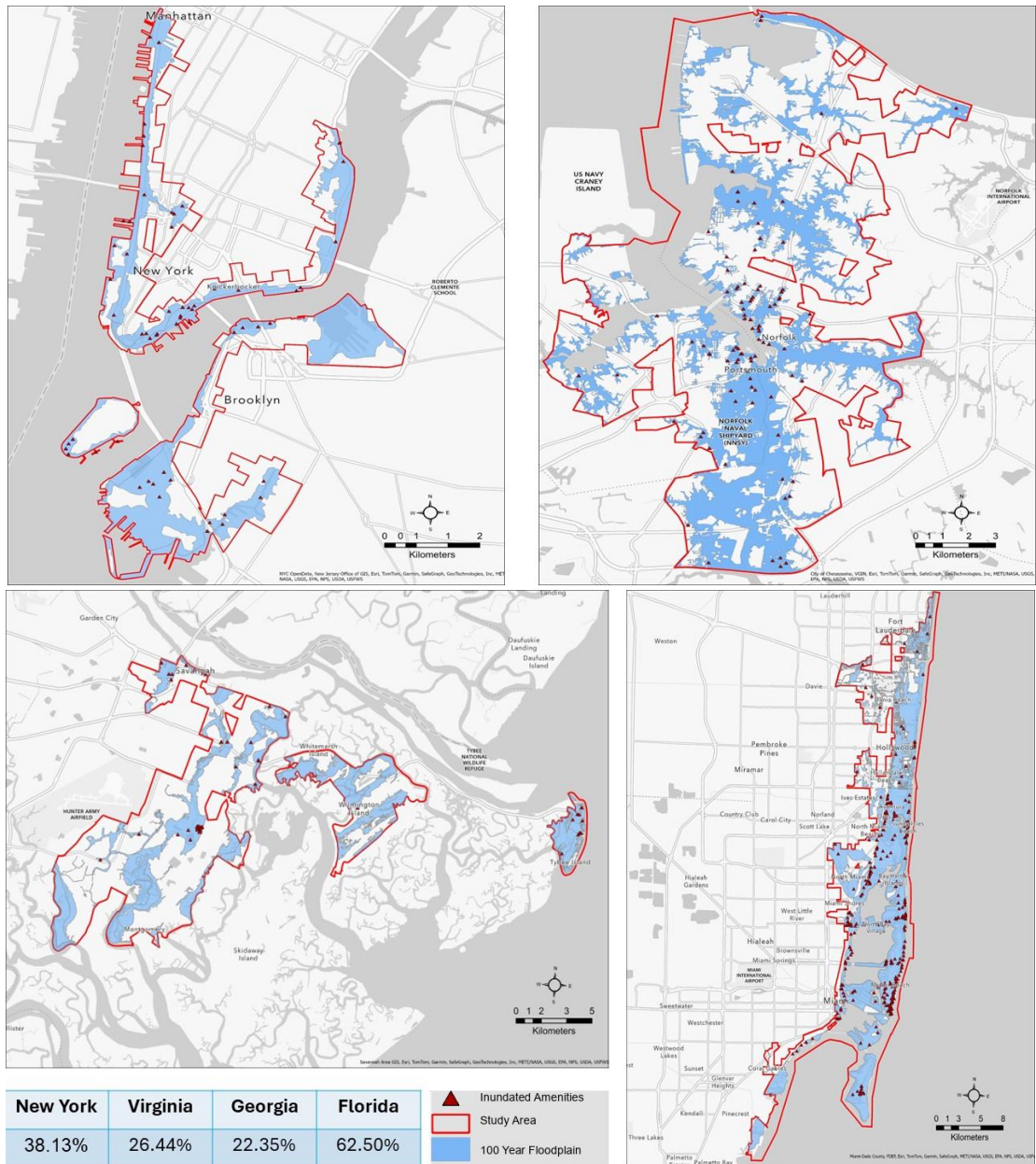


Figure 10. The percentage of services and amenities located in the FEMA floodplain zones within the relocation study locations

5.5. Buyouts

The FEMA Hazard Mitigation Grant Program (HMGP) database served as the primary dataset for this study, encompassing a comprehensive compilation of 33,806 projects spanning the period from 1996 to 2024. This analysis focused only on projects categorized specifically as coastal

acquisition and relocation of private properties within the database. Virginia had the highest percentage of allocated relocation and acquisition projects, representing 22.31% of the total funding in this period, followed by Georgia (13.73%) and New York (13.56%). Conversely, Florida had the lowest percentage of relocation/acquisition projects, comprising only 6.32% of the HMGP database entries (**Figure 11a**). Further investigation into our study locations of interest, has shown that Chatham County in Georgia had the highest percentage (20.67%) of acquisition or relocation efforts. In contrast, Norfolk and Portsmouth City in Virginia (1.53%), New York and Kings County (0%), and Broward and Miami-Dade County in Florida (0.55%) reported significantly lower percentages of such projects (**Figure 11b**).

In addition to the HMGP buyout programs, we investigated buyout initiatives administered at the local and state levels within our study area. Notably, New York implemented buyout programs supported by the Community Development Block Grant Disaster Recovery (CDBG-DR). This includes the NY Rising Buyout and Acquisition program and NYC Build it Back in both Kings County and New York County. These programs offer various relocation assistance options, such as construction services, and home acquisition across all boroughs of New York City (Moscovitz, 2018). Furthermore, the NYC Blue Buffers, a buyout initiative backed by \$250 million allocated from the 2022 Clean Water, Clean Air, and Green Jobs Environmental Bond Act, has also been announced by Governor Hochul's Press Office on January 9, 2024 (Governor's Press Office, 2024).

In Florida, the Rebuild Florida Voluntary Home Buyout Program, funded through CDBG-DR, plays a crucial role in reducing the risk of property loss and recurrent flooding by facilitating the purchase and repurposing of residential properties in high flood-risk areas (Brandon, 2019).

Conversely, our analysis revealed the absence of buyout programs, other than those supported by HMGP, in Norfolk City, Portsmouth City, and Chatham County.

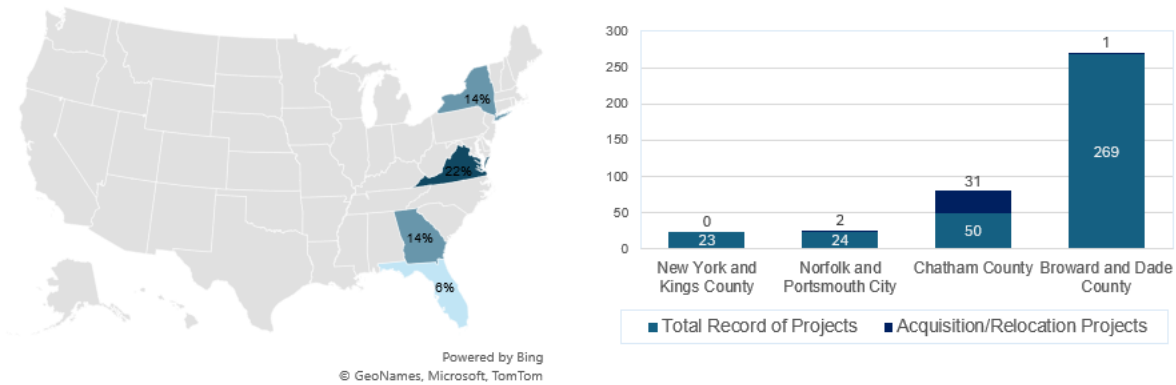


Figure 11. The percentage of relocation/acquisition projects by state with study study locations, and by County (b).

5.6. Comparable Housing

This analysis examined the housing availability within the relocation study locations and surrounding areas. It also compared the estimated home value of study locations with the inventory of vacant units in neighboring block groups within the same county. Given that a majority of respondents (52%) expressed a preference for local relocation, the comparison focused on vacant units within the same county.

Across all study locations in Virginia, Georgia, and Florida, there was a notable scarcity of vacant units of comparable value (**Figure 12**). Conversely, New York had more vacant units than occupied units for all price ranges except those valued at less than \$10,000 to \$49,000. Disparities were also evident in the distribution of occupied units across price ranges within each cluster. For

instance, the highest concentration of occupied units in Virginia fell within the \$100,000 to \$199,000 range, while in Georgia and Florida, it was within the \$200,000 to \$499,000 range. Conversely, in New York, most housing units were valued at \$500,000 and above. Notably, there was a pronounced deficiency in both housing units and occupied units valued at less than \$99,000 across all relocation study locations and their respective counties.



Figure 12. Total vacant units/total occupied units in four relocation study locations

6. Discussion

This study identifies the geographic study locations along the flood-prone urban areas of the US East Coast from New York to Florida, where residents are more supportive of relocation. With a growing number of residents considering relocation as a flood risk prevention measure, evaluating these study locations allows us to understand the potential causes and reasoning behind the

willingness to relocate. The key concerns influencing respondents' willingness to relocate in these study locations are crime rate, buyout programs, access to critical services and amenities, and availability of comparable housing in a similar community elsewhere. By studying factors such as crime rate and access to services and amenities, we can determine whether these concerns accelerate willingness to relocate and if the relocation process is made smoother and more feasible through buyout programs and comparable housing.

Our findings reveal the presence of four distinct study locations, with notable concentrations in New York, Virginia, Georgia, and Florida. The prevalence of relocation study locations in New York, Virginia, Georgia, and Florida can be attributed to the heightened risks posed by coastal flooding and barriers in implementing flood mitigation strategies. Norfolk, Virginia, for instance, stands out as a focal point, facing a multitude of challenges, including sea-level rise, nuisance flooding, and storm events (Ruckert et al., 2019). Research by Burgos et al. (2018) highlights the escalating frequency of nuisance flooding in Norfolk, with projections indicating over 200 flood events in the year 2049. Similarly, mean sea level measurements at Fort Pulaski, situated a few miles from Tybee Island, indicate an upward trend in mean sea level that is expected to accelerate in the coming decades, primarily due to the increased melting of ice sheets (Bormann et al., 2013). Several regions in Florida face various risk-inducing hazards, including storm surge, wind speed, precipitation, and sea level rise (SLR). Additionally, the geological composition of Miami-Dade County, characterized by porous limestone bedrock, poses additional challenges in implementing conventional flood mitigation strategies like seawalls due to hydrostatic percolation induced by sea-level rise (Woetzel et al., 2020). Our findings also correspond with previous studies identifying New York County and Miami-Dade County as hotspots of intensified urban development within

flood-prone zones (Qiang et al., 2017), underscoring the amplification of risks associated with coastal flooding in these regions. The identification of study locations of relocation and their drivers in this study has significant implications for policymakers, urban planners, and stakeholders involved in climate adaptation and disaster resilience. It highlights the need for targeted interventions to enhance the adaptive capacity of vulnerable communities, reduce hazard exposure, and promote sustainable development practices.

The socioeconomic profiles of respondents within the identified study locations offer valuable insights into the demographic characteristics of individuals with high relocation potential. Particularly, the predominance of younger adults aged 18-29, comprising 36% of the sample, suggests a higher frequency of younger adults considering relocation. This finding aligns with existing literature, which suggests that older individuals often exhibit a higher tendency to remain in the same location due to cultural attachment, familiarity with the environment, and physical limitations (Zickgraf, 2019; Cong et al., 2018; deVries and Fraser, 2012). Another notable finding of our study is the higher percentage of individuals within relocation study locations who lacked National Flood Insurance Program (NFIP) coverage compared to the total sample of 1450 respondents. This observation suggests that the absence of NFIP coverage likely influenced their willingness to relocate, as it may have been perceived as a more effective means of mitigating flood-related losses. This finding further supports the notion that while flood insurance has positive effects on community resilience (Han and Ye, 2022), publicly subsidized flood insurance inadvertently contributes to flood damages by altering incentives to reside in risky areas (Peralta and Scott, 2024).

The statistical analysis between the socioeconomic factors and top drivers of relocation revealed significant associations between income, home ownership, and ownership of flood insurance with the top drivers of relocation willingness. These findings suggest that economic factors play a critical role in shaping individuals' willingness to relocate in response to coastal flooding. Smith et al. (2006) found that economic differences influenced households' responses after Hurricane Andrew, with low-income households moving to low-rent housing in heavily affected areas, middle-income households relocating to reduce risk, and wealthy households with better access to insurance and self-protection generally remaining in their current residence. Similarly, econometric analysis suggests coastal county's annual economic growth rate declined by 0.45 percent, with 28% of this decrease attributed to the relocation of richer individuals from affected counties (Strobl, 2011). These studies highlight the significant impact of the economic status of an individual in relocation willingness, a conclusion which is further supported by our findings.

Based on the survey data indicating that the increase in crime was the primary factor influencing people to permanently relocate, our research sought to objectively assess the crime trends in the study area. Through the historical time series analysis, we uncovered a consistent and notable decrease in both violent and property crime reports across all the identified study locations of relocation. This result aligns with national trends in property and violent crime rates since the 1990s, as reported by the Bureau of Justice Statistics (BJS) and the Federal Bureau of Investigation (FBI) (Gramlich, 2024). Despite crime being cited as a potential influencing factor for relocation, the observed downward trend in reported incidents alleviates the concerns about crime in the study area. These results highlight the complexity of individuals' relocation willingness and the importance of empirically evaluating subjective factors in understanding migration patterns. Hipp,

2013 suggests that resident's perception of crime often does not correlate with the actual crime rate due to other factors such as the presence of disorder in the communities, media reports, and social networking in the neighborhood. Thus, relying solely on objective crime data may not provide an accurate depiction of crime, as this data often diverges from people's perceptions of crime.

When considering access to services and amenities as a key driver of relocation, our analysis revealed variations in the vulnerability of services and amenities across study locations of relocation, as evidenced by the percentage of infrastructure located within floodplain zones. Access to amenities is crucial not only in vulnerable regions but also in relocation destinations. For instance, Coastal North Carolina is recognized as a significant destination for migration due to the appealing amenities of its coastal region, which may attract newcomers (Crawford et al., 2013). Variations in the percentage of affected services and amenities indicate that flooding impacts regions differently—some more severely than others. So, it is crucial to understand the localized impacts of flooding on access to services and amenities. This understanding emphasizes the need for tailored, context-specific planning and relocation strategies.

Similarly, the examination of buyout initiatives in the study locations of relocation revealed varying levels of engagement and the number of projects across the counties of interest. The projects funded also varied across different regions. For instance, most of the buyout initiatives in Chatham County as well as Norfolk City and Portsmouth City were funded by HMGP whereas buyout initiatives funded by CDBG-DR were more prevalent in Broward, Miami-Dade, New York, and Kings County. Understanding the funding landscape and the distribution of buyout projects can aid policymakers in identifying gaps in funding allocation and targeting resources where they are most needed. Increasing buyout initiatives in areas where residents are more willing

to relocate holds the potential to foster equitable relocation processes by offering viable relocation options through buyout programs, individuals and families facing heightened disaster risks can access safer living environments with greater ease and support. This can also help alleviate the financial, logistical, and emotional burdens associated with relocation, thereby promoting social equity and resilience.

The study also identified that the shortage of vacant units of comparable value within study locations of relocation and adjacent areas poses significant challenges for individuals and families seeking to relocate from high-risk areas. The pronounced deficiency in units valued below \$100,000 further exacerbates the housing crisis, particularly for low-income households who may face limited options for affordable housing alternatives. In the context of flooding, although wealthier individuals may experience significant financial losses from severe inundation in terms of income, assets, and property value, poorer communities may suffer relatively greater damage due to their limited ability to cope with natural disasters (Wu et al., 2002). Similarly, increased storm frequency results in a 1.2–11.8 percent decline in average coastal land prices, driving households with lower incomes to relocate to these areas (Walls et al., 2018) and increasing their vulnerability due to limited options in already high-risk zones. This disparity not only impedes the ability of residents to access safe and secure housing but also exacerbates socio-economic inequalities within communities.

While this study provides valuable insights into the areas within the US east coast where respondents are more willing to relocate and the primary drivers influencing relocation willingness, there are a few limitations that need to be considered. Natural hazards can yield vastly different outcomes for individuals or communities, even when they experience similar levels of

hazard exposure (Felsenstein & Lichter, 2014). The spatial resolution of our analysis may overlook micro-level variations within study locations of relocation, such as neighborhood-level differences in flood exposure, socio-economic vulnerabilities, or access to resources. These nuances influence individual relocation decisions but are not fully captured in our aggregated analysis. Furthermore, the historical time series analysis of crime trends is subject to limitations in the available data sources, such as variations in reporting practices, changes in law enforcement policies, or underreporting of crime incidents, which could impact the validity and reliability of our findings. For instance, as the proportion of noncitizens and foreign-born individuals in a metropolitan area increases, crime reporting decreases, with a more significant decline observed for violent crimes compared to property crimes (Gutierrez & Kirk, 2017). Finally, the assessment of housing availability and the shortage of vacant units of comparable value is based on estimated values and may not fully capture the dynamic and heterogeneous nature of local housing markets.

While previous research on coastal relocation has identified various drivers influencing relocation willingness (Bukvic et al., 2015; Gibbs, 2016; Adade et al., 2023), our study takes a novel approach by providing an objective analysis of both push and pull factors within the context of real-world scenarios. Despite the limitations, we have contributed to the growing body of literature on climate adaptation and disaster resilience by providing empirical evidence on the drivers and dynamics of relocation in response to coastal flooding, specifically focusing on identified geographic study locations along the US East Coast. The findings have important implications for policymakers, urban planners, and stakeholders involved in climate adaptation and disaster risk reduction efforts, highlighting the need for targeted interventions to address socioeconomic vulnerabilities, promote

equitable access to housing, and enhance the resilience of vulnerable communities facing coastal flooding.

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Chapter 3: Conclusions and Summary

Coastal communities are increasingly threatened by episodic storm events and high tide flooding, both of which are becoming more severe and frequent due to climate change and rising sea levels. Adaptation strategies such as protection and accommodation are mostly preferred to mitigate these impacts but may prove insufficient and costly under the current climate change scenario and future sea level rise projection. In cases where the financial and social costs of protection and accommodation are higher, relocation could be a more efficient and sustainable adaptation strategy for effectively managing flooding risks. However, the spatially explicit research on reasons behind people's willingness to relocate in flood-prone urban areas is limited. This study offers critical insights into the study locations of heightened willingness to relocate across nine coastal states on the East Coast in response to coastal flooding. Using various datasets such as crime, housing values, buyout programs, and amenities and services within the different flood hazard zones, this study provides a comprehensive understanding of the drivers of relocation in those study locations.

Overall, our findings revealed that concerns such as crime increase and limited access to services and amenities that increase the willingness to relocate are not significantly prevalent in the study locations. While the lack of these drivers in relocation study locations may afford authorities additional time for the equitable planning of relocations, the absence of existing buyout programs and comparable housing options in similar communities elsewhere, particularly for low-income households, leaves individuals and families trapped in high-risk areas. This exacerbates their vulnerability to coastal hazards, disproportionately impacting low-income households even further. Furthermore, our findings also highlight variations in the drivers of relocation across different study locations such as a higher proportion of services and amenities exposed to flooding

in the Miami-Dade area in comparison to remaining study locations, highlighting the differential impact of flooding on various regions. These disparities are also evident in the administration of buyout programs across different relocation study locations. For instance, Chatham County, Georgia, despite experiencing relatively few coastal flooding events from tropical storms and hurricanes, had the highest number of buyout and acquisition projects. Conversely, New York, which is frequently impacted by major hurricanes, had no buyout or acquisition projects supported by the Hazard Mitigation Grant Program (HMGP). Thus, it is necessary to tailor context-specific planning and relocation strategies to effectively address the diverse needs and challenges faced by communities affected by coastal flooding. The findings of this study have important implications for policy and planning. Targeted interventions such as constructions to meet the housing needs of the population and maintaining low crime rates in urban areas are needed to address the socio-economic disparities that hinder the relocation process for vulnerable populations. Policies should focus on promoting equitable access to housing, enhancing the availability of buyout programs, and strengthening community resilience through improved governance and planning mechanisms. In urban areas, strategies such as vertical building, infill development, and subsidized housing programs can be implemented to maximize land use efficiency, accommodate population growth, and mitigate urban sprawl. Future research could build upon these findings by incorporating more comprehensive datasets and multi-level analyses to understand how micro-level socio-economic factors influence individual willingness to relocate within identified study locations. Moreover, examining variations in local governance and policy frameworks can provide insights into the effectiveness of relocation strategies and inform the development of tailored interventions to address the needs of diverse communities.

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Appendix

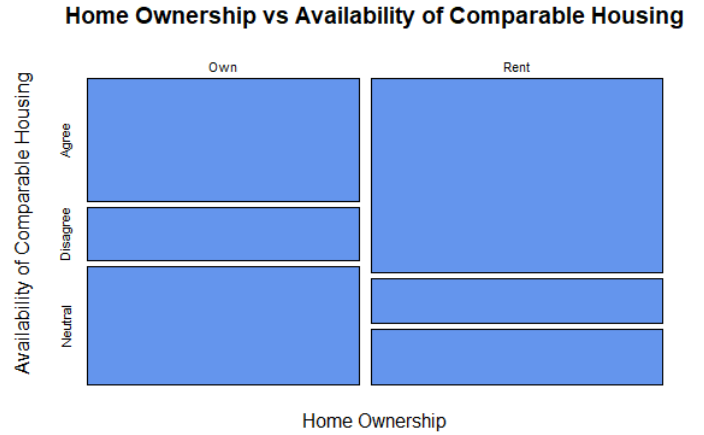
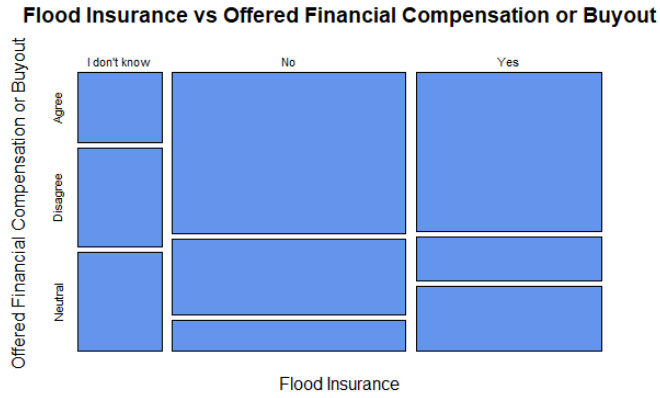
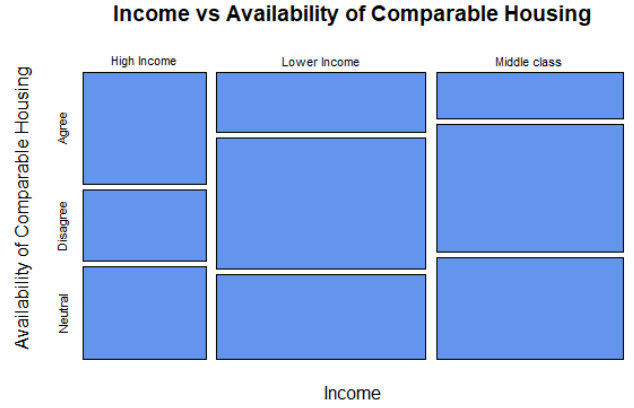
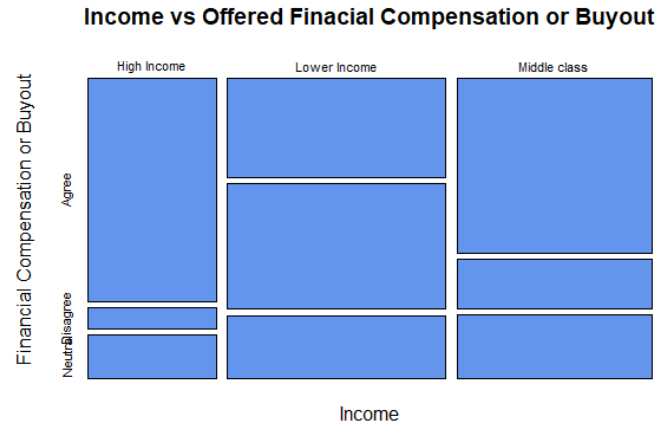


Figure A1. Mosaic plot of top drivers of relocation vs socioeconomic variables.