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Flood-induced mobility in rural and urban coastal jurisdictions: a homeowner's perspective

A. Bukvic[1] · **C. W. Zobel**[2]

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Abstract
Coastal flooding often exceeds homeowners' capacity to cope with repetitive damages and profoundly disrupts their livelihoods. Permanent relocation has been proposed as a solution for some coastal areas experiencing recurrent flooding and anticipating acceleration of impacts. However, it is unclear if homeowners living in such areas would support this strategy, where they would choose to go, and why. This study evaluates the willingness to relocate and the reasoning behind it among rural and urban homeowners residing in coastal high-risk areas. The rural versus urban comparison explores how attitudes toward relocation differ between these settings with distinct sociodemographic, economic, and cultural profiles. A mail survey administered on the Eastern Shore, Maryland, and in the Hampton Roads metropolitan area, Virginia, measured how willingness to relocate differs across the socioeconomic spectrum, prior flood exposure, concerns with flood impacts, and preferences for relocation destination. The survey responses were analyzed using descriptive and inferential statistics. The results show that more than one-third of respondents would consider relocating. The willingness to relocate was marginally influenced by socioeconomic factors and flood experiences and instead was significantly correlated with the risk of disastrous flooding, inadequate insurance compensation, and worsening crime. However, data show a clear shift in relocation support and the distance of the preferred destination from minor to significant flooding. Rural respondents are slightly less likely to relocate than urban ones. Descriptive statistics indicate nuanced differences in flood experiences, reasons to relocate, and preferences for a new destination between rural and urban populations.

Keywords Relocation · Migration · Coastal · Flooding · Sea level rise · Disasters

✉ A. Bukvic
ana.bukvic@vt.edu

C. W. Zobel
czobel@vt.edu

[1] Department of Geography, Virginia Tech, 207 Wallace Hall, 295 West Campus Dr, Blacksburg, VA 24061, USA

[2] Business Information Technology, Virginia Tech, 880 West Campus Drive, 1017 Pamplin Hall, Blacksburg, VA 24061, USA

1 Introduction

Many coastal areas face an uncertain future due to shifts in flood regimes, including increased frequency and magnitude of tropical storms (Emanuel 2021; Marsooli et al. 2019) and sea level rise (SLR) (Sallenger et al. 2012) that augments storm surges and subsequent damages in populated areas (Neumann et al. 2015). Changes in flood patterns indicate the growing need for adaptation across all coastal systems, either as a series of interconnected pathways (Barnett et al. 2014) or a fundamental change in how communities reduce vulnerability, such as permanent relocation (Fedele et al. 2019). In either case, identifying place-based contextual factors is a foundational step of effective adaptation for any location (Klein et al. 2000). Those factors, grounded in local culture, history, and values, will influence community and political support for different adaptation strategies (Griggs and Reguero 2021). While knowledge of physical flood protection using grey and green infrastructure is well established, it is less available for permanent relocation due to difficulties capturing evolving human behaviors. This paper addresses the empirical gap in understanding people's attitudes towards relocation in coastal communities challenged by chronic and episodic flooding. It uses survey data to evaluate the reasons driving the willingness to relocate among rural and urban coastal homeowners.

Relocation may become a realistic option for residents with limited copying capacity and ability to adapt. Knowing what must be done to adapt does not always translate into action. For example, a cross-scale analysis of 226 coastal adaptation policies across the globe revealed that only half of them are implemented, with most not reflecting climate risk and being prevalently focused on urban areas (Olazabal et al. 2019). There is also a risk that such policies favor in-place adaptation strategies over permanent relocation, which, according to Gibbs (2016), may be deliberately overlooked due to its political risk and distributional impacts, especially if considered a proactive measure. Another consideration that may affect the relocation risks is the coping capacity (Smith and Wandel 2006) or the skills and resources available to deal with the impacts of hazards or disasters (Gaillard 2010). In the context of SLR, coping capacity reflects the cumulative contributions of individuals and their relationship with other local community structures (Klein and Schmidt-Thomé 2006). It is also closely related to distributional issues like wealth and income, affecting the financial ability of residents to deal with flood risk (Felsenstein and Lichter 2014). Changes in socioeconomic characteristics, environmental conditions, and flood hazards can overwhelm the coping mechanisms of even more self-sufficient and resourceful communities (Few 2003). On the other hand, relocation can increase coping capacity with flooding (Mensah and Ahadzie 2020).

The household decision to employ relocation as an adaptive strategy is shaped by many personal factors, such as flood experiences, values, culture, and history. Several surveys have explored preferences for relocation, participation in buyouts, and attitudes toward managed retreat. For example, according to Seebauer and Winkler (2020a), the decision to relocate is primarily influenced by financial costs, and if they are similar between staying and moving, then other psychosocial factors like place attachment and anxiety about future flooding become important. Individuals with a stronger place attachment prefer to remain in their community and support in-situ strategies, normalizing their risk and coping capacity (Holley et al. 2022). Based on a questionnaire administered in two Bay County communities in Florida, researchers found that respondents were primarily concerned with finding a

job in a new location and with their safety when considering relocating, preferring options that would allow them to preserve their family and social networks (Song and Peng 2017). Survey respondents living in the flood-prone Mississippi River Delta in southern Louisiana who are willing to consider moving are prevalently younger renters dissatisfied with their current living conditions and experienced flooding (Correll et al. 2021).

Another survey of Old Saybrook's residents in Connecticut shows that they have high flood risk awareness but diverge on how to address it, revealing more concerns about impacts on natural resources, infrastructure, and community services than on the increase in taxes, insurance rates, and development restrictions (Johnston et al. 2015). Interviews conducted in areas affected by Hurricane Sandy show that awareness of coastal impacts is unrelated to risk tolerance, preferences for different solutions, and willingness to act individually to deal with flooding (Wong-Parodi et al. 2017). A household survey of New York City neighborhoods also affected by Hurricane Sandy further indicates that homeowners who adopted modest adaptation strategies are 80% less likely to relocate in the future but would reconsider their decision if observing their peers relocating, flooding becoming more frequent, or property values depreciating (Buchanan et al. 2019). Another survey conducted in this area three years post-Sandy shows that buyout participants had lower place attachment and social capital than those who stayed and recovered in place and were located next to the buyout area (Binder et al. 2018). People affected by repetitive flooding tend to support flood reduction efforts, including relocation, especially if they are less attached to the homes and communities that shape their identity (Kick et al. 2011). Still, many residents prefer less expensive flood control strategies, which are easy to implement and are promoted or required by the locality, especially for costly properties with emotional significance for the occupants (Brody et al. 2017).

The most common mechanism for implementing relocation is via buyout programs. Robinson et al. (2018) found that people's participation in buyout programs is based on their location and proximity to flood risk, length of tenure in the home, experience with prior hurricanes, perceived vulnerability, and being White. Fraser et al. (2003) noted a divergence in risk perception between buyout program officials, who tend to be more focused on the future flood risk, and residents, who are more concerned with the financial aspects, availability of affordable housing, and loss of social networks in surveyed communities in North Dakota and North Carolina. In Canada, a national survey found that people are socially receptive to buyouts in flood-prone areas if they are voluntary, transparent, externally funded, and offer different compensation options and monetary incentives (Raikes et al. 2023). However, De Vries and Fraser (2012) noted that many surveyed buyout participants found these programs involuntary as administered by officials representing government interests. The decision to relocate is also affected by the availability of buyout programs, participation criteria, the available compensation, and the specific funding stipulations favoring neighborhoods that experience more damage and flooding (Fu and Gregory 2019). Despite the growing awareness of the buyout programs and related cost-benefits, less is known about existing forced relocation in low-lying areas and the associated social injustices (O'Donnell 2022). Even though many studies discuss programs and financial mechanisms for coastal relocation as an adaptive strategy (e.g., Peterson et al. 2020; Greer et al. 2022) and offer projections of large-scale coastal migration (e.g., Hauer et al. 2024; Lincke and Hinkel 2021), there is notably less research focused on understanding the fundamental reasoning behind the decision to relocate. Similarly, Greer et al. (2022) found that although the buyouts literature is

growing, it is prevalently focused on buyout experience, buyout practice and implementation, housing policy, flood reduction, and justice and equity, and not on the circumstances leading to buyouts.

This study measures considerations influencing the decision to relocate and the selection of relocation destinations from a purposive sample of rural and urban homeowners residing in areas with heightened flood risk. It uses descriptive and inferential statistics of survey data of 103 responses to provide empirical evidence of reasoning driving relocation preferences. Thus far, there is no national or regional baseline of relocation preferences, mainly due to complexities in obtaining high-resolution primary data in high-risk locations already experiencing substantial research fatigue and saturation. This increasingly common data collection barrier likely also affected our sample size. Regardless, our survey offers an invaluable perspective on relocation from some of the most physically vulnerable coastal areas in the U.S. with heightened relocation risk. It also intentionally captures insights from both urban and rural populations to provide a more inclusive assessment. In addition to highly urban Hampton Roads, Virginia, the survey was conducted in two rural coastal counties on the Delmarva Peninsula in Maryland with preserved coastal rural character. Such rural areas often have higher flood risk, more socially vulnerable populations, a flood-sensitive economy, a lower tax base, and fewer individuals trained in flood prevention (Rhubart and Sun 2021). Small satellite communities tend to receive less support for adaptation to SLR due to their remoteness and distance from the central government institutions (Bhattachan et al. 2018). They are also at an adaptive disadvantage due to their dependence on fewer industries to sustain their livelihoods, limited access to relevant data to inform their actions, fewer stakeholders vested in policymaking, and limited political power and visibility (Fitton et al. 2021). The Hazard Mitigation Grant Program (HMGP) assistance allocations awarded between urban and rural counties from 1989 to 2018 show substantial inequalities in the distribution and duration of HMGP assistance, with more funds and planning time allocated to urban than rural counties, leaving "rural counties in the dust" (Seong et al. 2022, pg. 1).

Coastal Virginia and Maryland are known for their heightened risk of compound flooding, exacerbated by the high relative SLR. Current flooding estimates might underestimate what may transpire in the future by failing to account for comprehensive compound impacts caused by extreme rainfall, storm surge, and river discharge augmented by high tides and strong winds that may push water upstream—a common scenario in the Chesapeake Bay (Kerns and Chen 2022). Rezaie et al. (2021) found that floodplain can increase 1.3–2.3 times in low and 2.1–4.7 times in high SLR projections, leading to $5.8–8.6 billion in damages and 1-1.2 million people affected in the Chesapeake Bay area, and making current protection of little value to address future risks. The heightened relative SLR primarily reflects land subsidence due to groundwater withdrawal, causing subsidence rates of around 2.8 mm/year in southern Chesapeake Bay (Eggleston & Pope, 2013). This geographic area, which includes the Hampton Roads area, is also prone to frequent and expansive nuisance or recurrent tidal flooding, causing localized traffic disruptions (Praharaj et al. 2021). The literature review on flood risk and adaptation in Maryland found that even a modest SLR will have considerable impacts on the coastline and tidally-influenced waterways, potentially leading to a significant loss of infrastructure and economic impacts (Teodoro and Nairn 2020). In Hampton Roads, storm-surge flooding will further affect the most socially vulnerable populations with limited ability to cope with and prepare for its impacts (Kleinosky et

al. 2007). Even though coastal adaptation strategies exist to control episodic and chronic flooding in coastal areas, such as protection (e.g., green infrastructure and shoreline hardening), accommodation (e.g., early warning system and building codes), and retreat (e.g., rolling easements, setbacks, and relocation), it may take 20–30 years for their implementation (Mitchell et al. 2013).

In Virginia, the total area exposed to relative SLR is expected to be 424 square miles in 2040 and 534 square miles in 2060, including a significant portion of roads and buildings affected even by minor tidal flooding (McLeod et al. 2020). These anticipated SLR scenarios would increase the risk of extreme flooding, especially around mid-century when rare flood events become a more common occurrence, putting at risk 200,000 homes, 4,500 miles of roads, 77 schools, five power plants, 535 EPA-listed hazardous waste sites, and sewage treatment facilities, and a portion of Department of Defense installations (Norfolk Naval Station, Norfolk Naval Shipyard, and Joint Base Langley-Eustis) located below 9 feet of elevation (Strauss et al. 2014). The low-lying areas of Hampton Roads also have a high storm surge risk, especially in the south and along the eastern edge of the region, where even weak or moderate hurricanes can lead to substantial flooding (Kleinosky et al. 2007). Two rural counties on the Eastern Shore peninsula in Maryland also have a high flood risk, with Dorchester experiencing a 3.9 mm/year SLR increase and 1.67 m increase by 2100 and Talbot experiencing a 3.48 mm/year and 1.49 m increase (Nature Conservancy 2016). Like in Hampton Roads, the accelerated relative SLR will amplify storm surge exposure in this rural area and subsequent damages to the built environment, with a typical flood depth increase of 30% in 2050 and 50–70% by the end of this century (Li et al. 2020).

2 Methods

Survey locations Urban municipalities Norfolk, Hampton, Portsmouth, and Virginia Beach represent independent cities in the Virginia Beach-Norfolk-Newport News Metropolitan Statistical Area (MSA). Even though these municipalities are physically and socioeconomically interconnected, their socioeconomic context varies (Appendix I: Table A1). Virginia Beach has the highest land area and population but the smallest population density, with some parts still preserving their rural character. It also has a notably higher percentage of the affluent, wealthier white population and homeowners than the other three cities. Norfolk has the lowest rate of older residents and the highest percentage of rental properties. Hampton and Portsmouth have similar sociodemographic characteristics. Two neighboring rural counties, Talbot and Dorchester, on the Eastern Shore in Maryland, also differ in size, socioeconomic characteristics (Appendix I: Table A2), and cultural, fiscal, and historical context (Bukvic and Harrald 2019). Compared to Dorchester County, Talbot County is smaller and more populated, with greater residential density and a Whiter, more educated, and older population. It also has higher income and lower poverty levels. Dorchester is the second largest Maryland county, with agriculture and forestry being primary economic activities, followed by the seafood industry, which provides a livelihood for many coastal villages (Cole 2008; MD Department of Commerce 2019). These factors could shape the willingness to relocate and affect relocation decision-making because of stronger place attachment and dependence on water- and land-based economic activities, in contrast to the often more transient urban areas vested in the service economy. Socioeconomic characteristics can also

drive such decision-making by placing more weight on relocation drivers that reflect unique age, educational, or employment opportunities-related needs.

Survey approach and design The survey was administered in the geographic areas within the inundation corridors identified by Mitchell et al. (2023) that indicate a 2% annual exceedance probability (AEP) of storm surge flood risk using the 2015 North Atlantic Coast Comprehensive Study's statistical coastal flood hazard data at different Sea Level Rise (SLR) scenarios (Fig. 1). To identify survey recruitment areas, we selected addresses of homeowners within the combined inundation raster layers that show flood exposure based on the present, 2030, 2060, and 2090 SLR projections. This raster was then converted into a polygon separating flood-prone versus non-flood-prone areas. The inundation polygon was intersected to identify all residential parcels of land that may be inundated under any SLR scenarios (present to 2090).

Urban geospatial parcel-level data were obtained from the Hampton Roads Geospatial Exchange (HRGEO 2020) and rural data from the MDProperty View database (Maryland Department of Planning 2020). The selected residential parcels were then converted into point features. Density-based clustering with self-adjusting distances identified clusters of home addresses representing neighborhoods within the study locations. The clustering was performed to identify areas with more densely populated cohesive residential neighborhoods that would allow more efficient survey recruitment and have higher socioeconomic cohesion. The minimum cluster size in Hampton Roads was 200, while the minimum in the Maryland counties was 100, to account for lower population density in rural locations. Clusters adjacent to major waterways exposed to flooding were selected for surveying. Addresses within the clusters were selected using the GIS random sampling tool to ensure

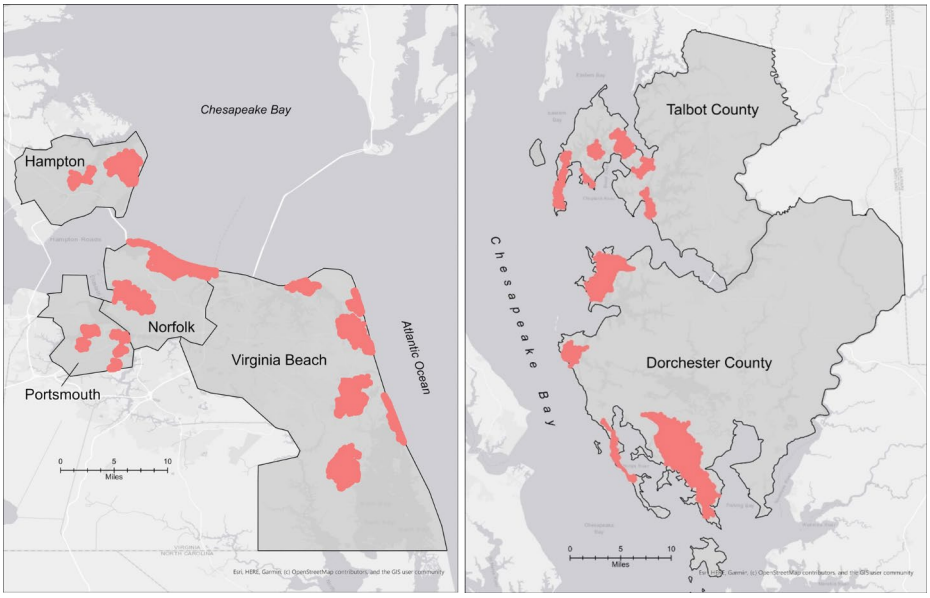

Fig. 1 Survey recruitment areas (Cities of Hampton, Norfolk, Portsmouth, and Virginia Beach in Virginia, and Dorchester and Talbot County in Maryland)

that the sample is proportional to the size of the cluster to meet the targeted number of addresses (200 in each Hampton Roads municipality and 400 in each of Maryland counties). Each locality had addresses attached to the parcel data except the City of Hampton. These addresses were obtained from the city's property information system using parcel IDs (City of Hampton 2020).

We used purposive sampling, targeting only residents living in flood-prone inundation corridors of interest in selected rural and urban geographic locations. The survey was administered to homeowners 18 years of age or older who speak English via mail to comply with the COVID-19 pandemic IRB restrictions on Human Subject Research in person (IRB #19–586). Virginia Tech's printing services mailed out 1,600 survey packages on July 28, 2020, consisting of a recruitment statement, consent form, and survey to 800 parcels in Hampton Roads (200 in each: Portsmouth, Norfolk, Hampton, Virginia Beach) and 800 on the Eastern Shore (400 in each county: Dorchester and Talbot). The paper survey consisted of 18 quantitative and two open-ended questions listed in the same order in all mailed packages (Appendix II). Most survey instruments were replicated from previous research that validated the effectiveness of survey instruments in measuring attitudes toward relocation (Bukvic et al. 2015). The response rate was 6.5% ($n=103$), likely due to the COVID-19 pandemic circumstances and the survey's difficult topic. The surveys were digitized, transformed into binary independent variables, and used in descriptive and statistical analysis. A Pearson's Chi-square test for independence and a multinomial logit model described in Appendix III assessed the relationships between the dependent variable (willingness to relocate: yes, maybe in the future, and no) and the independent variables for the other survey questions. This analysis was performed in R.

3 Results

The survey results show that 36% of respondents would consider permanently relocating due to flooding, 49% would consider doing so in the future, and 15% would not. The sample had 34 rural responses (24 in Dorchester County and 10 in Talbot County) and 69 urban responses (22 in Norfolk, 12 in Portsmouth, 14 in Hampton, and 21 in Virginia Beach). The respondents' socioeconomic profile is available in Appendix I, Table A3. In summary, 55% of respondents were over 60, 88% were white and well-educated, and 75% completed college and graduate degrees, mostly with medium to high income, part-time employment, and retired status. Considering our recruitment strategy solely focused on the coastal areas with the highest flood risk that might face the risk of flood-induced relocation, our sample is not representative of their respective municipalities and prevalently captures older, more educated, and whiter residents. Additional geospatial analysis could provide more insights into the population distribution within each municipality based on their sociodemographic and economic profile and assess whether such a subgroup tends to reside in locations closer to the coastline. A correlation analysis using Pearson's Chi-square test found that only education ($p=0.0455$*) was significantly associated with willingness to relocate, primarily due to less educated respondents (Less than High School, High School, and Other) being more likely to relocate and the most educated group being more likely to say Maybe. In addition, a combined full and part-time employed variable demonstrated significance ($p=0.0329$*),

with 62.7% of the unemployed responding Yes and 23.3% responding Yes, with 46.7% of those who are also employed responding Yes.

Exposure and impacts The majority of respondents experienced flooded roads (64%), followed by flooded yards (51%) and parking lots (38%) more than five times, while most never experienced flooded homes (78%) (Fig. 2, top right). Among flood impacts, respondents most commonly experienced school delays and closures (59%), difficulty commuting to work (58%), yard/tree damage (54%), business delays and closure (54%), and canceled doctors and other appointments (37%) (Fig. 2, left). They were least likely to experience an increase in crime (2%), difficulty obtaining homeowners insurance (11%), neighbors moving out and renting their homes (17%), and damage to personal items in the house (18%). One-quarter of respondents observed neighbors moving out and selling their homes. Pearson's Chi-square Test for Independence was also run on each of the six exposure variables, and none of them were found to be significantly statistically correlated with willingness to relocate. Thus, although 92.3% of those who did experience damage answered "Yes" or "Maybe" to be willing to relocate, 82.2% of those who did not experience damage also chose one of these two options. Among the fourteen flood impact responses, only "Difficulty commuting to work" was significantly associated with willingness to relocate, albeit only at the $p<0.1$ level ($p=0.0652$). Of those who experienced such difficulty, 91.2% said either Yes or Maybe to relocation, and of those who did not, only 76.2% said either Yes or Maybe to the possibility of relocating.

Relocation drivers In the combined "agree and strongly agree" categories, most respondents said that they would permanently relocate if they experienced disastrous flooding (74%), if insurance would not cover all damages (73%) and if crime worsened (70%) (Fig. 3). These three considerations also dominated the strongly agreed category with 47%, 46%, and 39%, respectively. Other pressing reasons for deciding to relocate were house damages (63%), the buyout offer (59%), experience with significant flooding (58%), and limited access to services (51%). The respondents disagreed and strongly disagreed that they would relocate if they only experienced sporadic (73%) or frequent minor (61%) nuisance flooding.

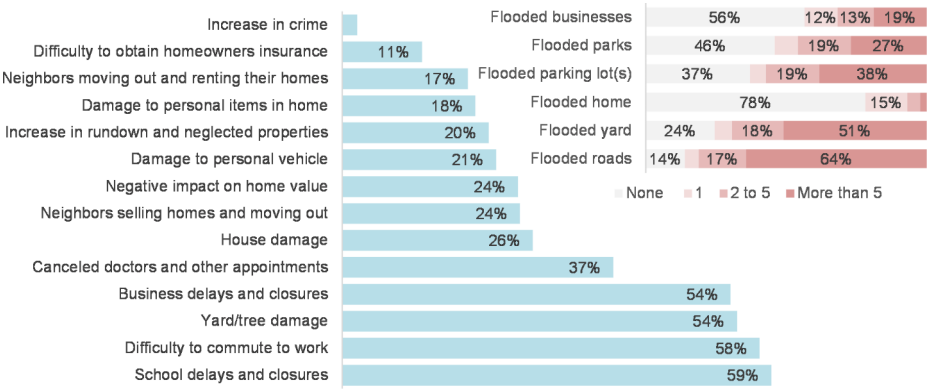

Fig. 2 Survey responses in percentages to questions "What types of flood events have you experienced in your community and how many times?" (top right) and "Up to this date, which of the following did you experience due to flooding in your community?" showing "Yes" responses (left)

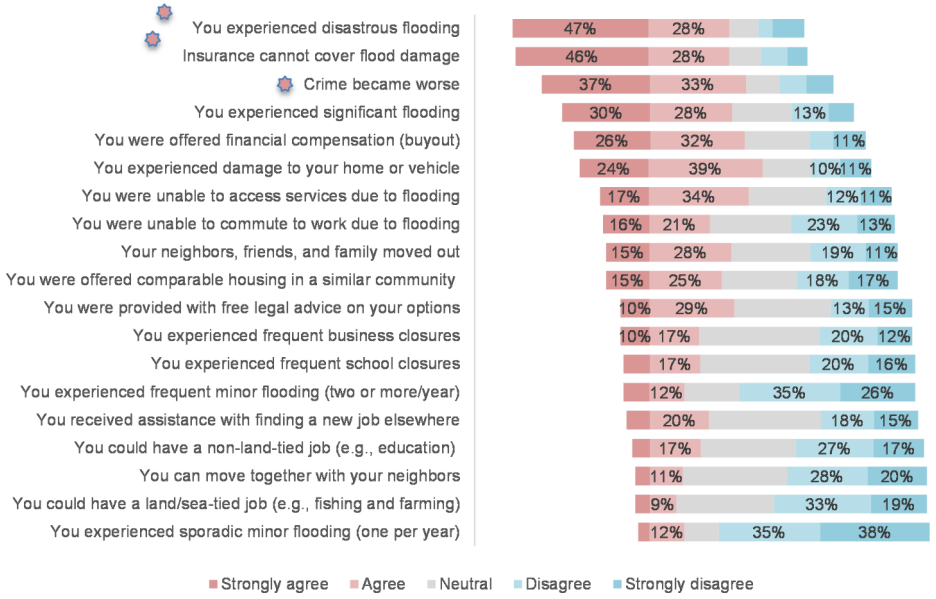

Fig. 3 Survey responses to the question "Would you consider relocating from this community due to coastal flooding if?" ranked by Strongly agree category in percentages (those significantly correlated to the willingness to relocate are marked with a star icon)

The responses that received the least favorable agreement were the possibility of moving together with their neighbors (16%) and the availability of a land/sea-tied job (14%). The most neutral reasons to relocate were frequent school closures (38%), frequent business closures (42%), and assistance with finding a new job (39%). Generally, the likelihood of relocating increases as the intensity of experienced flooding increases (Fig. 3). However, the relationship is not entirely linear because there is a much bigger difference in outcome between the set of larger events and the set of smaller events than between the individual types of events in each case.

In a follow-up open-ended question about the most critical factors influencing respondents' decisions to relocate due to coastal flooding, many noted concerns with exposure to storm surges, rising sea levels, higher tides, land sinking, and increased flood frequency. When talking about flooding, respondents expressed their concerns using adjectives such as recurring, severe, severity/frequency, occasional, extreme, catastrophic, constant, continued, persistent, major, dangerous, disastrous, and seasonal. These descriptive words indicate respondents' concerns with flood duration, frequency, spatial extent, and severity, suggesting different tolerance levels towards the risk manifestation. Many respondents mentioned chronic flooding as a reason to relocate. As flood impacts leading to relocation, respondents listed substantial or total property damage, the projected decrease in property values, direct flooding of property and home, anxiety/stress/ worry about flooding and recovery, driving through the water, power outage, loss of landline and internet (especially if only Digital Subscriber Lines service is available), well-water contamination, impassable roads, and school closures.

Respondents sometimes used a specific reference when describing their relocation threshold, e.g., impacts lasting more than two days or more than twice a year, indicating different tolerance ranges. Most were concerned with impacts on their homes and their intensification (e.g., frequent, significant, constant, and closer to the house), leading to compound problems and financial costs (e.g., "constant destruction of property that would lead to our asset becoming a liability"). Outcomes of flood exposure would also contribute to the decision to move, e.g., inability to obtain house insurance, dealing with insurance claims, a substantial decrease in property value, unreliable access to amenities such as grocery stores and gas stations, failure to see family and go to work, associated costs, impacts on personal safety, job loss, impacts on family, neighbors moving out, and inability to use the property as wanted. Other more personal concerns included aging/advanced age and the related need for advanced medical care and proximity to family, the importance of raising a family in the same area, crime, job safety, enjoyment of the coastal natural environment (scenic marsh/bay/beach, wildlife), and loss of historical character of the place. Some respondents expressed concern with moving costs, uncertainty about their options, and finding an alternative location nearby if they serve as caregivers for a family member, share child custody, or need to be closer to specialized health care and facilities accepting military benefits. Noted benefits that would ease relocation include the compensation for home acquisition and coverage of moving expenses, employment opportunities elsewhere with the same pay, lower flood risk, milder weather, "same community vibe," personal safety, same suburban or urban setting, a college town, progressive politics, retaining access to the waterfront, and ability to move together with family or to be closer to them. One respondent pointed out issues with and the importance of local government to effectively address community flood problems.

The second open-ended question asked respondents to list a specific tipping point or threshold of the decision to relocate in response to flooding. Home damage and increased crime are the most commonly noted tipping points. Here, the respondents also used descriptive words referring to the intensification of flooding as a tipping point. Some respondents mentioned the intolerable duration of flood exposure (e.g., roads remain flooded for more than two days or are unpassable at all times). Many also listed the anticipated decrease in property value, total or catastrophic property loss, personal security/safety, community decline (e.g., poor school quality/performance, children missing school, socioeconomic decline, and feeling uncomfortable), and financial implications (e.g., no resources for dealing with flood problem, insurance claims, and increasing cost of living). Other reasons to move were inability to repair damages, reduced access to amenities, regular evacuations, street flooding, closure of services and amenities, failure to obtain home or car insurance, decreased quality of life, land loss, loss of life, availability of buyout programs and offered compensation, negligence and poor response from the city, and neighbors moving out.

Other reasons to relocate The responses associated with the reasons to relocate besides flooding were split into two groups for comparison based on the respondents' ages (Appendix I, Figure A1). A majority of both the younger group (age 19–59) and the older group (age 60+) either agreed or strongly agreed that they would relocate to be closer to their family and friends (68% and 64%, respectively). The two groups were also similar in their responses to the relevance of places of cultural or sentimental importance (32% / 33% agree or strongly agree, and 41% / 38% neutral). As one might expect, however, being closer to

hospitals and health care services was more important for the older group (39% younger and 52% older answered agree or strongly agree). In contrast, the importance of being closer to better job opportunities (61% younger and 21% older) and to schools (33% younger and 8% older) was either agreed with or strongly agreed with to a much greater extent by the younger group.

Preferences for selection of relocation destination When respondents were explicitly asked where they would relocate in response to different types of flooding and community-level impacts, the only answers significantly correlated with the overall willingness to relocate were those associated with disastrous flooding and increased crime. In the case of catastrophic flooding, most respondents would prefer to stay in the same region (27%) or to move to a different state (26%), followed by relocation within the same county (16%) or the same state (15%), and then the same community but a different neighborhood (11%). Only 5% of respondents would move to another home within the same neighborhood. The results were similar for the increasing crime, with respondents preferring to move within the same region (28%), a different state (19%), the same county (16%), a different neighborhood within their current community (16%), and to the same state (12%). Only 9% of respondents would consider staying in the same neighborhood. The matrix for flood exposure variables shows a clear shift in preferences for relocation destinations from minor flooding to more significant flood events (Appendix I: Table A4). For sporadic and frequent minor flooding, respondents would prevalently choose to relocate to a different house in the same neighborhood (36% and 28%, respectively) or within the same community (21% and 27%). The preference for staying locally erodes for significant and disastrous flooding, while that for moving regionally, statewide, and out of state increases. The only notable consideration for the community-level flood impacts that would prompt respondents to move further distances is crime increase.

The respondents were also asked where they would prefer to relocate due to coastal flooding in general. The results were similar to those mentioned above, with most preferring to stay in the same region (29%) or to move to a different state (24%). To a lesser extent, respondents would choose to stay in the same community but move to a different neighborhood (15%), another home in the same neighborhood, or elsewhere within the same state (11% each). Only 9% of respondents would want to stay in the same county. Overall, most respondents would prefer to relocate within the same region. Respondents were also asked what type of setting they would choose to move to. Although the results were not significantly correlated with the decision to relocate, the majority of respondents would prefer to move to a suburban setting (44%), followed by rural (32%) and then urban (22%).

Rural versus urban perspective Descriptive statistics show that rural and urban responses differ across several categories. Rural respondents were older (64% vs. 50% age 60 and above), whiter (100% vs. 84%), and less educated (76% vs. 84% with college, graduate, or certificate degree). Half of the urban sample was fully employed, 9% part-time, and 29% retired, while in the rural group, 43% of respondents were full-time employed, 14% part-time (14%), and 43% retired. Rural residents were also less wealthy than urban ones, with 65% of urban respondents earning over $75,000 and 23% below this amount, and 44% of rural respondents having income above $75,000 and 42% below. Fewer urban respondents

lived in the same home for ten or more years (49%) versus 59% rural. Almost half of all urban residents were affiliated with the military, primarily as veterans (29%) and then as spouses of active duty family members (17%) or active duty personnel (3%). In the rural area, only 35% of respondents were affiliated with the military. Many more rural residents had National Flood Insurance Program (NFIP) flood insurance policy (76% vs. 65%). A higher number of rural residents experienced roadway (74%) and yard (73%) flooding more than five times (60% vs. 39%) than the urban group. Another substantial difference was in the experience with flooded homes, with 33% of rural homeowners having their homes flooded vs. 17% of urban. On the other hand, the rural residents experienced less flooding of the parks, parking lots, and businesses, perhaps because there are fewer in the rural setting. As for the specific flood impacts, urban residents experienced more issues with commuting to work (63% vs. 47%) and school delays and closures (63% vs. 52%). In rural areas, respondents experienced more damage to vehicles (30% vs. 17%) and houses (34% vs. 22%), personal items in the home (31% vs. 8%), negative impacts on home value (38% vs. 18%), neighbors selling homes and moving out (32% vs. 21%), and increase in rundown and neglected properties (38% vs. 12%). Both groups practically did not experience any increase in crime. Rural respondents would mostly prefer to stay in the same region (36%) or move to a different state (30%) and, to a lesser extent, remain in the same county (15%), same neighborhood (12%), and same community (6%). Urban respondents would also primarily like to stay in the same region (30%), followed by different state (21%), same community (19%), same state (13%), same neighborhood (10%), and same county (6%). The majority of rural respondents would move to another rural area (67%) and then suburban (18%) and urban locations (15%), while urban would mostly move to suburban areas (58%) and, to a lesser extent, to urban (25%) and rural (16%).

3.1 Regression analysis

Correlations were generated between each of the responses above, and the results were used to derive a multinomial logit regression model to assess the relative contribution of each variable to the willingness to relocate due to flooding (Fig. 4, Appendix IV: Table A4). The dependent variable (*willingness to relocate*) had three levels: "No," "Yes," and "Maybe in the future," while "No" was specified as the reference category. In our sample, 36.7% of respondents were willing to relocate, 15.3% were not willing to relocate, and 48% would consider doing so in the future. The sample was further classified based on the respondents' residence in a *rural* or *urban* setting, using the street addresses associated with the survey responses. An initial regression model was constructed to include the interaction between these two settings and the most relevant independent variables. This model was then iteratively refined by assessing the significance of the model at each stage and removing the independent variables or interaction terms with VIF values greater than 5.0. The final model had a high R-squared value (R^2: 0.48525) and minor residual deviance among all the tested models. Both sub-models (Yes versus No and Maybe versus No) indicate that many more significant variables are associated with being willing to move than with maybe doing so in the future. The two significant variables in the Maybe category are gender (females being more likely to say No versus Yes or Maybe to relocate than men) and the offer of comparable housing elsewhere (with respondents more likely to say Maybe to relocate than No).

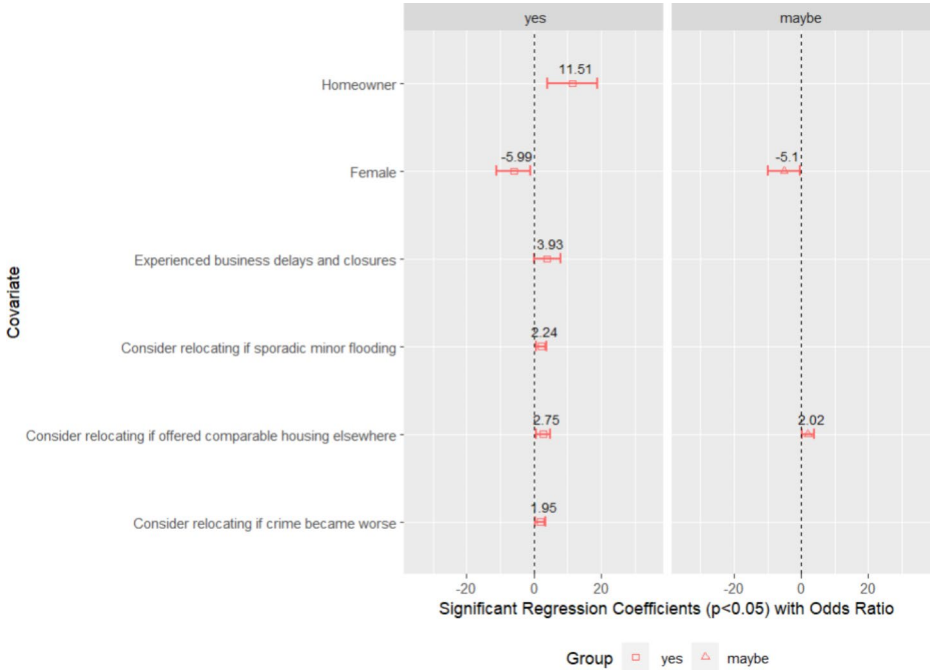

Fig. 4 The multinomial logit model shows significant results when comparing Yes and Maybe responses to No (Yes, $n=31$; No, $n=15$; Maybe in the future, n-45)

Concerning willingness to relocate versus not, the model shows that homeowners, respondents who would experience sporadic minor flooding and worsened crime and are offered comparable housing elsewhere, are significantly more likely to relocate. The same is true for respondents who experienced business delays and closures, although to a lesser extent. Although there are no significant interactions between rural and urban responses and other binary variables at $p<0.05$, urban females are more likely to relocate than males at a lower significance level, implying that urban females are slightly more likely to relocate than rural females.

There is only a five-point difference in willingness to relocate between urban and rural respondents (38% urban vs. 33% rural). Further, only 9% more rural residents would not consider relocating (12% urban vs. 21% rural). To the question, "If respondents would consider relocating from this community due to coastal flooding," in the strongly agree and agree category for periodic minor flooding, responses are similar between urban and rural samples. However, with an increase in the frequency of minor flooding, urban respondents' support for relocation triples in the strongly agree category. Overall, urban respondents are more likely to consider relocation in response to minor flooding than rural respondents (20% vs. 6% for sporadic and 27% vs. 9% for frequent minor flooding in combined strongly agree and agree categories). Urban respondents are also more likely to relocate if they experience significant and disastrous flooding and house or vehicle damage than rural ones. Twice as many urban respondents would consider relocating if businesses experience interruptions or have to close due to flooding than the rural respondents. More urban respondents would relocate if crime worsens (76% vs. 57%) and neighbors, friends, and family move out (46

vs. 35%) than the rural group. The option to obtain land- or water-based employment was more important to rural respondents (23% vs. 10%).

When asked about other reasons for permanent relocation besides flooding in "strongly agree and agree" categories, more urban residents would like to be closer to friends and family (67% vs. 59%), better job opportunities (46% vs. 26%), schools (24% vs. 10%) and places of cultural or sentimental importance (36% vs. 25%). Rural residents prefer to be closer to hospitals and health care (56% vs. 41%). As for the specific location, rural and urban residents would choose to stay in the same region (30% each). Next, urban residents would prefer to relocate out of state (21%), remain in the same community but in a different neighborhood (19%), and stay in the same state (13%). Rural respondents would mostly prefer to move out of state (30%) or stay within the same county (15%). Three times more urban residents would choose to stay in the same community than rural ones. For the desired setting, urban respondents would prioritize relocation to suburban areas (59%), followed by urban (25%) and rural (16%). The vast majority of rural respondents would prefer to stay in rural settings (67%), with fewer moving to suburban (18%) or urban (15%) locations.

4 Discussion

The main objective of this study is to understand what is driving preferences for permanent relocation among rural and urban residents living in flood-prone coastal corridors in the Mid-Atlantic region. The survey shows that more than one-third of respondents would permanently relocate due to flooding, and only 15% would not. Socioeconomic variables were not associated with willingness to relocate except education and employment, with less educated and full- and part-time employed more likely to relocate. Most respondents experienced flooding in their surroundings (e.g., roads, yards, and parking lots) but not in their residences (78%). The results were almost identical when the data was normalized by the length of time each respondent lived in their current home. The most common impacts included school delays and closures, difficulty commuting to work, yard damage, and business disruptions and closures. The least experienced flood impacts were crime increase, difficulty obtaining home insurance, damage to personal items in the home (reflecting negligible house damage), and neighbors moving out and renting their homes. However, 25% of respondents noticed neighbors moving and reselling their homes, which may continue in flood-prone communities due to the lack of residential property disclosure for prior flooding in Maryland and Virginia.

Even though many respondents experienced flooding and its impacts, two exposure questions were not significantly correlated with willingness to relocate. Yet, most open-ended responses listed flooding as a primary reason to move. One reason for such discrepancy could be that surveyed households did not yet reach the flood-related threshold for this decision. Descriptive statistics show that more respondents would be more likely to relocate if they experienced disastrous flooding (74%) than sporadic or frequent minor flooding. On the contrary, Bohra-Mishra et al. (2014) found that disasters are less likely to lead to permanent relocation than sustained chronic hazard impacts. The other most notable reasons to relocate were inadequate insurance coverage that would not compensate for all damages, crime increase (even though most respondents did not yet experience any related to the flooding), house damage (also a rare occurrence), and a buyout offer. There is a clear trend

shifting from "Maybe in the future" to "Yes" responses with flood risk intensification. The respondents would not relocate if they only experienced sporadic (73%) or frequent (61%) minor flooding. This result may reflect their confidence in coping with occasional flooding due to already implemented flood prevention measures or experiences that did not result in substantial damages and psychosocial impacts. Other personal reasons to relocate include the closer proximity to family and, to a lesser extent, healthcare facilities, amenities, and better job opportunities. The least important considerations in relocation decision-making were the possibility of moving together with their neighbors (16%) and the availability of a land/sea-tied job (14%). Most respondents would prefer to stay locally and move to a suburban setting, followed by rural and the least urban locations. However, the only responses significantly correlated with the overall willingness to relocate were those associated with experiencing disastrous flooding, inadequate insurance compensation, and worsening crime. The last concern likely reflects an anticipated aspect that might be related to an expected community decline due to repetitive flooding, something that has been observed in the literature as a factor in relocation reasoning (Fraser et al. 2003; Bukvic and Barnett 2023).

The matrix for flood exposure variables shows a clear shift in preferences for relocation destinations from minor flooding to more significant flood events. The literature widely explored the relationship between flood exposure and migration intentions. One study found that fear of flooding and flood damage primarily drives the decision to sell the property and move out of the floodplain (de Koning et al. 2019). Hurricanes, coastal storms, and floods lead to increased out-migration to nearby and even more distant locations, generally to areas with a lower risk of future events (Sheldon and Zhan 2022). Ekoh et al. (2022) found that prior experience with flood severity statistically affected risk perceptions and, consequently, future migration intentions. Similarly, Duijndam et al. (2022) observed that past encounters with flooding were strong predictors of migration intentions in flood and SLR-prone areas of Vietnam. For the exposure to sporadic and frequent minor flooding, respondents often chose to relocate to a different house in the same neighborhood (36% and 28%, respectively) or within the same community (21% and 27%, respectively). With significant and disastrous flooding, the preference for staying locally diminishes, while it surges for relocation to the same region or state and out of state. Crime increase is the only significant factor prompting respondents to move greater distances among the community-level flood impacts.

The regression model identified a few predictors of the decision to relocate: owning a home, experiencing sporadic minor flooding, more crime and business closures, and being offered comparable housing elsewhere. The regression model did not find a significant difference between rural and urban responses. However, urban and rural respondents differ in many ways. Rural residents are only 5% less supportive of relocating than urban residents and 9% less likely to reject this option. The rural sample is whiter, older, less educated, with fewer full-time and more part-time employees, while at the same time experiencing more flooding and more damage. At the same time, rural residents appear more resilient, with higher numbers having the NFIP policy and higher tolerance for flooding before considering relocation. Very few rural respondents would relocate due to sporadic or frequent minor flooding. They would be more likely to relocate due to significant or disastrous flooding but still less than urban respondents. Urban respondents are more likely to relocate if businesses close or operate irregularly, friends, family, and neighbors move out, and crime worsens because of flooding. They would move to be closer to friends and family, better job opportunities, schools, and places of cultural and sentimental importance than rural respondents.

On the other hand, rural respondents would consider relocating to be closer to hospitals and healthcare. An urban growth model simulating SLR risk in Brisbane, Australia, indicates that relocation may be a more effective strategy for rural areas than densely populated developed urban areas that may benefit from physical SLR protection (Wang et al. 2021). This model confirms the need for a differing approach to coastal adaptation of rural and urban areas, including managing relocation risks. Another argument for shifting attention to rural areas is their propensity for compounding socioeconomic impacts, where relocating population might include younger and more adaptable residents, leaving older, less resilient ones behind (King et al. 2014).

This study evaluated a comprehensive set of potential relocation drivers that stem from previous research, namely qualitative primary data. Some considerations were likely overlooked due to sample characteristics. For example, having children can strongly motivate willingness to relocate (Fraser et al. 2003). For instance, Kirschenbaum (1996) found that the intent to relocate is closely related to concerns about children's psychological well-being. Seebauer and Winkler (2020b) observed that fear of flood impacts on children's prospects played a decisive role in their willingness to relocate, primarily to ensure that flood-affected houses don't become a financial burden or liability. This survey did not ask about the family structure but relied on the school closure questions to capture subpopulations with school-age kids as a proxy measure. Even though most respondents (59%) observed school delays and closures due to flooding, only 26% agreed and strongly agreed this would be an important factor in their decision to move. The survey also collected information on the affiliation with the military, considering that this geographic area has a substantial number of military families due to its proximity to coastal military installations and supporting facilities. We were interested to see if military experiences (e.g., resilience to harsh conditions and mobility) and training (e.g., discipline and self-sufficiency) might affect willingness to relocate among this subpopulation. Overall, we found that the most notable difference between the civilian and military populations was among 'yes' responses, with a higher number of civilians (41%) saying yes to relocation than those affiliated with the military (30%). More military affiliates would consider relocating in the future (54%) than civilians (45%). Military families may have a different tolerance threshold and confidence in coping with adversarial situations than the civilian populations.

We also found that employment and education are linked with a willingness to relocate, with less educated and full- and part-time employees more likely to relocate. De Vries and Fraser (2012) found no statistical relationship between educational attainment and the acceptance of buyout offers in a telephone survey among property owners in four different urban flood-prone locations. Further, our results show that almost one-quarter of respondents (24%) observed neighbors selling homes and moving out. Ando and Reeser (2022) state that the expectations of neighbors' responses significantly drive willingness to pay (WTP) for a proactive binding relocation contract activated upon major structural damage that would expedite the buyout process. Thus, this observation may mean that more residents may consider relocating once they notice their neighbors doing so in response to flooding to ensure they are not the last standing house on the block. Even though Binder et al. (2018) found that social capital and networks have a central role in relocation outcomes, in our survey, only 16% of respondents would consider relocating with their neighbors.

This preference only slightly varies between rural and urban respondents, with 13% of the rural sample agreeing and strongly agreeing they would relocate if able to move together

with their neighbors, compared to 18% of urban residents. This finding is consistent with Bukvic and Barnett (2023), where most surveyed coastal residents would not care about moving with their neighbors. It might be possible that those willing to relocate feel they could still maintain the same social relationships from a new location, either by staying nearby or relying on technology to stay connected with their social circles. The social relationships within the community are very complex and influential in the decision to move. For example, a community survey of Oakwood Beach and Rockaway Park residents found that place-based factors like previous flood exposure, local culture, and sense of place play an important role in buyout participation (Binder et al. 2015). Respondents who reported greater social support also noted higher flood tolerance and confidence in collective adaptation efforts, affecting their decision to stay or move in response to flooding (Wong-Parodi et al. 2017). Households that have already undertaken some adaptations may be less likely to consider other more preventative options like buyouts due to single-action bias with implications on strategies that must be adjusted to changing risk (Buchanan et al. 2019).

Even though a significant body of literature is exploring the concept of relocation, buyouts, and managed retreat, fewer studies use quantitative primary data to elicit relocation attitudes among at-risk populations in a systematic and transferable manner. Some results of this study are consistent with previous surveys measuring willingness to relocate. For example, Elliott and Wang (2023a) found that voluntary flood-driven relocation is a highly local process that can reduce flood risk but with ethnic and racial connotations where mostly white communities are more likely to stay and cope than relocate to more racially diverse areas. The findings of this study based on the secondary data are aligned with our survey results, indicating a preference for local relocation. When probing preferences for relocation destinations, we intentionally did not use numerical ranges but terms with a more relevant meaning for the general public, which may introduce some ambiguity on how individual scales are defined. Even though 29% of our respondents would stay in the same region (Eastern Shore or Hampton Roads) and 24% would move to another state, 46% would remain locally within the same county. Elliot and Wang (2023b) found most buyout participants moved within 7.4 miles of driving distance, with 58% retreating, staying within a 10-mile drive of their original location and 74% within a 20-mile drive. Respondents in another study on relocation intentions in two flood-prone communities in Australia indicated a willingness to relocate (23% and 32%), preferably to a different part of the town, with fewer considering a different community (King et al. 2014). Considering the spatial distances in our rural study areas and neighborhood size in urban locations, staying locally has a broader meaning, often referring to a larger area than described in the study above.

Bukvic and Barnett (2023) found that the key predictors of willingness to relocate are crime, future flood risk, community support during crises, higher property taxes, proximity to amenities, low hazard and disaster risk, and offer of comparable housing in similar community elsewhere, and not the prior exposure and experience with flooding. It also showed that the most common impacts are difficulties commuting to work and school delays and closures. In our study, although older age was not significantly correlated with willingness to move, 55% of respondents were over 65, and 34% were retired, indicating the importance of capturing relocation perspectives from this subpopulation. A longitudinal survey of older adults revealed that while they may be pushed to move by a disaster, their relocation planning is primarily driven by the pull of improving their residential situation, which also predicts whether they would consider moving altogether, mainly reflecting their physical

health (Erickson et al. 2006). Another concept explored in the context of flood risk in cohesive coastal rural communities like Tangier Island, Virginia, is relocation in place that is less invasive than far-distance dislocation and can be achieved by elevating the structure or moving it elsewhere on the same lot or down the street (Moore and Acker 2018).

Our results also complement the body of literature focused on the economic reasoning in mobility decisions. For example, Kline and Moretti (2014) note that the influx and outflux of people in an area may affect the local cost of living and housing market, causing further ripples in housing demand. Harris and Todaro (1970) highlight the economic aspects and employment needs as important migration drivers in both rural and urban communities. In addition, other attributes like pollution, crime, racial profile, and access to business hubs often drive labor mobility (Roback 1982) that may cross-pollinate with flood risk mobility in coastal communities.

Empirical evidence will be increasingly important in informing policies to address mobility in the coastal zone. For example, improving understanding of people's reasons and concerns for moving could advance efforts facilitating support for the cultural transition of accepting relocation out of the floodplain as an effective way of preventing hazard exposure (de Koning et al. 2019). Science-based policies may have a detrimental role in shaping this discourse, considering the reluctance to change the paradigm that prioritizes staying in place based on political risk, especially if introduced proactively (Gibbs 2016). Another reason for the hesitancy to consider this adaptation strategy stems from the profoundly personal psychosocial impacts relocation may have on the families and the adverse outcomes observed from past relocation efforts (Perry and Lindell 1997). Interviews and focus groups conducted in Staten Island, NYC, post Hurricane Sandy revealed substantial political and financial barriers to implementing relocation programs if introduced without a major disaster or consecutive flood events (Braamskamp and Penning-Rowsell 2018). Thus, due to the lack of impactful manifestation of flood hazards, other push and pull forces may play a more dominant role in relocation-decision making, incentivizing proactive relocation efforts. Emphasizing other benefits of moving beside the flooding, such as better economic opportunities, improved housing, and safer streetscape, has lower political risk and simultaneously tackles multiple community objectives. Thus, additional research should focus on measuring the role of various pull and push forces, their relationship, and their impact on the decision to voluntarily move while recognizing that some households and communities do not wish to relocate. It should also aim to understand why this immobility is rooted in sociocultural, political, and emotional values that may surpass estimates solely based on the flood risk and justify investment in other options besides leaving (Farbotko et al. 2020).

The questions used in this survey replicate prior studies conducted in different geographic areas with statistically validated survey instruments. The format balances the needs of surveying modality (e.g., mail, phone, online, or in-person), the complexity of questions (e.g., multiple choice, Likert scale, and open-ended), and effort (e.g., time for voluntary vs. compensated input). The survey length and type of inquiries were carefully developed to answer research questions while making them accessible to diverse coastal populations. Thus, some elicited responses use common simplified terms to refer to processes and outcomes that are more complex in real life. Neither are they using terminology that could be polarizing or emotional, distracting from the two key concepts, flooding, and relocation risk. We are mindful that relocation decision-making is more complex and emotionally challenging in

the real world than what was captured in our survey. We had to omit some more nuanced questions to achieve adequate survey response and retention rate for the statistical analysis.

Further, this survey was initially envisioned as a door-to-door data collection planned for May 2023. Considering this period also marked the first few months of the COVID-19 pandemic, we had to adapt the survey modality to ensure no in-person contact with respondents. Despite the $5 gift card incentive per completed survey, we still had a low response rate of 6.9%. Even though the sampling approach was carefully devised to reach random households in flood-prone rural and urban locations, our final sample had twice as many urban responses (69 vs. 34). This sampling issue limited our statistical analysis and the generalizability and transferability of our findings to other similar coastal locations. Lastly, our sample may not represent all populations in the study area, and it is not intended to do so. The discrepancy stems from our purposive sampling strategy targeting only homeowners living in the narrow flood-prone shoreline corridors compared to the rest of the city and county that might have low flood and relocation risk. Often, those locations are inhabited by people who need to be close to water to tend to their boats and engage in a water-based economy or those who choose to live close to water and often pay more for access to this commodity.

5 Conclusions

Relocation is increasingly proposed as a coastal adaptation strategy for flood risk reduction where other in situ options are not economically, physically, or technically viable. Scientific and policy discourse on relocation has evolved over the last decade, namely calling for a more integrated and nuanced relocation planning process and implementation, from the initial public engagement to the assessment and support of relocation destinations. However, policymakers need tangible empirical evidence to justify their relocation decisions, such as land use changes, development regulation, resource allocation, and improved buyout programs. Our results reaffirm the importance of some relocation drivers, such as concerns about future flooding, crime increase, and insufficient insurance compensation, in alignment with existing literature. The same holds for the preferred relocation destinations that are predominantly local. However, findings also provide evidence of new nuances in relocation reasoning, such as the role of gender, education, employment, and type of flood exposure, that should be explored in future research. For example, we found that the concerns with the anticipated intensity of flooding may affect not only the willingness to relocate but also the distance of such a move. This result indicates different tolerance levels at the intersection of what respondents experienced and what they expect to experience in the future. Thus, the role of risk perceptions in the decision to relocate warrants further research attention.

Further, we observed novel differences in relocation perspectives between rural and urban surveyed populations. Even though they were not statistically significant due to our small sample size and imbalanced representation of urban versus rural respondents, they indicate that these two populations may have dissimilar perspectives on the risk and possibility of moving due to coastal flooding. Lastly, our analysis identified a few predictors of relocation, namely homeownership, experience with sporadic minor flooding, increased crime and business closures, and an offer of comparable housing elsewhere. Even though some of these concerns have already been identified in the literature as relocation drivers,

our survey further reinforces their importance in relocation decision-making. Consistent evidence about the key attributes influencing coastal mobility can encourage their broader use as indicators in geospatial analysis and inform the development of computer models and simulations using secondary data. It can also embolden officials to take a fresh perspective on future mobility within their jurisdictions and policy interventions that could improve relocation outcomes while minimizing its impact on communities.

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