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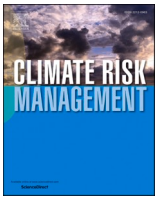

# Living with water: Evolving adaptation preferences under increasing sea-level rise in Miami-Dade County, FL, USA

Nadia A. Seeteram [a,b,*], Elizabeth P. Anderson [a], Mahadev Bhat [a], Kevin Grove [c], Brett F. Sanders [d,e], Jochen E. Schubert [d], Farrah Hasan [f], Katharine J. Mach [g,h]

[a] Department of Earth and Environment and Institute of the Environment, Florida International University, Miami, FL 33199, USA
[b] Columbia Climate School, Columbia University, New York, NY 10025, USA
[c] Department of Global & Socio-cultural Studies and Institute of the Environment, Florida International University, Miami, FL 33199, USA
[d] Department of Civil and Environmental Engineering, UC Irvine, Irvine, CA 92697, USA
[e] Department of Urban Planning and Public Policy, UC Irvine, Irvine, CA 92697, USA
[f] School of Marine and Environmental Affairs, University of Washington, Seattle, WA 98195, USA
[g] Department of Environmental Science and Policy, Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA
[h] Leonard and Jayne Abess Center for Ecosystem Science and Policy, University of Miami, Coral Gables, FL, USA

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ABSTRACT

Great uncertainty exists about household responses to intensifying sea-level rise and related flooding, especially about when residents may consider relocation. Understanding how preferences for in-situ adaptation versus climate mobility evolve through time across communities with varying capacities can help identify policy solutions suited to a range of community needs. We present an analysis of 40 interviews and 597 survey responses from residents of Miami-Dade County, FL, USA—an area of substantial and increasing flood-related risk where concerns related to climate mobilities are emerging. We integrate new flood hazard models depicting chronic inundation and 1%-annual-chance flooding with street-level detail under increasing sea-level rise, which when combined with the interview and survey data reveal the multiplicities of spatiotemporal risk. Overall, we find that up to 75% of all participating respondents have experienced precipitation-based flooding in recent years, and "new normal" experiences of inundation are already reshaping current decisions to move. However, up to 57% of survey respondents preferred in-situ adaptations over moving away, highlighting a need for society-wide commitments to long-term adaptation. Socioeconomic pressures dominated climate mobility considerations among interview and survey respondents, raising climate justice concerns over socially inequitable mobility outcomes. Examinations of differential climate mobility pressures and preferences for adaptation increase understanding of the transformations reshaping coastal communities today to guide more equitable societal adaptations in the future.

## 1. Introduction

Sea-level rise (SLR) and related flooding will contribute to migration from coastal communities, as direct and indirect impacts

* Corresponding author at: Columbia University, 2190 Broadway, Level A, NY, NY 10025, USA.
*E-mail address:* nas2215@columbia.edu (N.A. Seeteram).

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increase over time (Seeteram et al., 2023). In recognition of these future challenges, pressing research questions exist as to when and how people might choose to migrate and where they may relocate. Previous studies have modeled climate migration patterns, but these patterns are difficult to quantify and predict given the complexity of migration decision-making processes (Burzyńskia et al., 2019; Davis et al., 2018; Duijndam et al., 2022; Hauer, 2017). As such, scholars have called for research agendas to consider the multiplicities of climate-related movement, or *climate mobilities* (Boas et al., 2022, 2019; Wiegel et al., 2019). The shift to climate mobilities allows researchers to critically examine how migration decisions are shaped by a multitude of factors including risk perceptions, differential exposure to hazards, determinants of social vulnerability, and adaptation policies.

Mobility in response to SLR and related flooding may become increasingly common where adequate adaptation responses and coastal protection are lacking. Understanding how climate-related pressures may drive future mobilities could result in more targeted adaptation interventions (Black et al., 2011; Foresight, 2011; Hauer et al., 2020). Mobility in response to climatic impacts and risks can take many forms whether voluntary or involuntary (e.g., participating in a voluntary buyout program versus being displaced after a climate-related disaster), or temporary or permanent (e.g., temporary displacement versus permanent relocation; Ajibade et al., 2020; Hauer et al., 2020; McLeman and Hunter, 2010; Wiegel et al., 2019). Applying a "mobilities" perspective to understand permanent, more deliberate decisions to move allows for examinations of the multiple pressures that can lead people to become mobile, or immobile, whereas a "migration" oriented focus may obscure these nuances in favor of understanding unidirectional mass movement (Boas et al., 2022; Sheller and Urry, 2006; Wiegel et al., 2019). Climate-related mobilities can originate from direct risk, such as physical exposure to SLR related-flooding, or indirect risks, such as second-order impacts on housing and landuse resulting from changing flood hazards (Seeteram et al., 2023). In line with this conceptualization, we pay specific attention to the varying considerations within climate mobility decision-making processes that influence choices, such as perceived risk, as opposed to predicting migration outcomes.

Inherent within climate mobility decision-making is the level of perceived risk, a primary component of the Protection Motivation Theory (PMT), which in recent years has been used to understand determinants of risk-mitigation behavior in response to flooding (Adams, 2016; Botzen et al., 2019; Bubeck et al., 2018; Rogers, 1975; Weyrich et al., 2020). PMT posits that social and economic considerations drive adaptive behavior, specifically an individual's threat appraisal and coping appraisal. *Threat appraisal* refers to the process by which individuals assess how they would be negatively impacted by a hazard and is a function of risk perception influenced by experience with potential hazards (Aerts, 2020; Slovic, 1987; Weyrich et al., 2020). *Coping appraisal* refers to the process by which individuals assess the effectiveness of mitigation actions and their own ability to carry out the measures (Aerts, 2020; Weyrich et al., 2020). Recent studies that examine residential behavior in response to SLR or flooding risks uphold the principles of PMT, whereby respondents preferred responses they believed were effective and feasible to carry out (Botzen et al., 2019; Bubeck et al., 2018; Treuer et al., 2018). While PMT may be effective in measuring certain adaptive behaviors, particularly those associated with structural measures or in-situ adaptations, PMT may not be sufficient in predicting more complicated decisions, such as climate mobility decision-making in response to hazards. Decisions to move in response to climatic change are multi-faceted in their consideration of cultural and socioeconomic contexts, government policies, nonlinearities of climate change, individual preferences, access to information, perceived risk, and social vulnerability (Adams, 2016; Fussell et al., 2014; Hauer et al., 2020; Kopp et al., 2019). Social vulnerability is a particularly influential determinant of adaptive capacity as it shapes individual options (Adger et al., 2018).

Miami-Dade County (MDC), FL, USA, is a county within South Florida whose population is at substantial risk from SLR, raising concerns of future out-migration. SLR will increase MDC residents' exposure to flood-related hazards from tidal, precipitation, coastal, groundwater, and compound events, as well as to permanent inundation over time (Hauer et al., 2021a; Peña et al., 2022; Sukop et al., 2018; Wdowinski et al., 2016). Seeteram et al. (2023) estimated 54.7 % of all current residents could be impacted by permanent inundation as SLR increases from 1 m to 2 m of SLR, and ultimately 92.2 % of current residents by 3 m of SLR. In recognition of the severe realities of SLR in South Florida, Treuer et al. (2018) used simulations to observe adaptive behaviors among South Florida residents at various time points under increasing SLR. The study found that 18 % of the sample intended to move within the next five years in 2016, and this intention increased to 41 % in 2050 when SLR was depicted at its highest. However, Treuer et al. (2018) considered out-migration from MDC without consideration of differential climate mobilities. MDC is an area with high income and racial inequality, a legacy of its discriminatory past, and is considered the second most unequal metropolitan area in the United States (Gini coefficient: 0.508) with 47.8 % of its population employed in low-wage service work (Connolly, 2014; Florida and Pedigo, 2019; Portes et al., 2018; UM Office of Civic and Community Engagement, 2016). Varying levels of societal vulnerability suggest varying climate mobility pressures in the absence of strategic policy interventions.

Previous research in Miami-Dade County assessed differential climate mobility pressures through the creation of a framework that categorized communities as *stable*, *migrating*, *displaced*, or *trapped* based on direct and indirect SLR risk (Seeteram et al., 2023: SM 1). *Stable* communities experience relatively low mobility pressure due to low SLR impacts and are generally resilient due to higher adaptive capacity. *Migrating* communities are more exposed to SLR impacts and flooding, but their financial stability and lower social vulnerability allow for individual risk mitigation, such as leveraging social and political capital for publicly sponsored home buyouts (Seeteram et al., 2023). *Displaced* communities reflect lower flood risk areas where resilience investments and people will flow to and where current residents with higher levels of social vulnerability may be unable to withstand these economic forces, leading to displacement from their neighborhoods. Finally, *trapped* communities reflect residents who are highly exposed to SLR impacts, have higher levels of social vulnerability, and may find themselves facing immobility pressures (Seeteram et al., 2023). Using high-resolution flood exposure models and a county-specific assessment of social vulnerability, Seeteram et al. (2023) estimated that up to 69 % of current MDC residents could be trapped under high SLR scenarios and that 5 % of current residents were most at-risk from displacement pressures resulting from increased desirability for safer, more resilient areas for housing and development. The framework in Seeteram et al. (2023) provides a mechanism for understanding these pressures through consideration of exposure to

dynamic SLR impacts, but the extent to which the framework reflects the lived experience and decision-making process of MDC residents is unknown.

Here, we build off the considerations from previous studies in Miami-Dade to further understand the current impacts of SLR and related flooding and their influence on adaptive behaviors and climate mobility concerns within the region. Our experimental design incorporates in-depth interviews and a county-wide online survey among MDC residents coupled with flood hazard models to contextualize resident perspectives given current and future flood exposure. As such, our analysis includes (1) coded responses from 40 semi-structured interviews, (2) online survey responses from 597 MDC residents, and (3) projections of flood exposure under increasing SLR scenarios modeled through the fast-response, fine-resolution Parallel Raster Inundation Model, or PRIMo (Sanders et al., 2022; Sanders and Schubert, 2019; Seeteram et al., 2023). Through the interviews, we aimed to surface and understand the range of resident perspectives on how changing levels of flooding influence adaptation and mobility decisions at present and in the future, and how these preferences and perspectives align with potential climate mobility pressures from Seeteram et al. (2023). The climate mobility framework from that study provides a simple, but effective method for understanding potential climate mobility outcomes for residents of coastal communities based on varying levels of societal vulnerability and flood exposure through time. Then, through a representative survey countywide, we aimed to understand the prevalence of these perspectives across MDC residents, integrating PMT to understand how risk perception influences adaptation and mobility decisions. Finally, we combined the lived experiences expressed within the interviews and surveys with modeled flood hazard results using the framework in Seeteram et al. (2023) to assess how future migration intentions align with predicted mobility pressures, such as the potential for residents to be (1) *Stable*, or minimally exposed to SLR, (2) *Migrating*, or directly exposed to SLR with capacity to relocate, (3) *Displaced*, or indirectly exposed to SLR through economic pressures, and (4) *Trapped*, or directly exposed to SLR without capacity to relocate. We consider the policy and research implications from the insights generated through this assessment and offer considerations for future climate adaptation planning.

## 2. Material and methods

In this section, we outline our methodological approach. We first describe the interview (1) scope and protocol and (2) recruitment and sampling strategy. Next, we describe (3) survey development, (4) experimental design (including the residential flood exposure modeling), (5) the survey data collection effort, and (6) our analytic approach integrating the projections of flood exposure, interviews, and surveys.

### *2.1. Interview scope and protocol*

Interviews followed a semi-structured protocol that assessed residents' experiences across five main themes to facilitate directed qualitative content analysis. The themes included: (1) general questions about living in MDC, (2) SLR and flooding impacts, (3) financial stability, (4) past mobility patterns, and (5) attitudes towards moving due to SLR and flooding. Our main goal in evaluating these five themes was to contextualize potential climate mobility pressures that residents may be experiencing now or may experience in the future. See Appendix A for the interview protocol.

### *2.2. Interview recruitment and sampling strategy*

Our interview recruitment strategy was implemented online due to limitations during the COVID-19 pandemic. We created a Google form and attached it to a digital flyer, which was circulated by community and study partners at local non-profits, resilience agencies, and community leader networks. Interested residents filled out the form and were contacted if they met the study criteria. We prioritized a geographically diverse sample across MDC to aid evaluations of the direct and indirect SLR impacts for residents living at various points along the county's elevation gradient. We also prioritized residents who were 25 years of age or older, had lived in MDC for more than a year, and were not employed within environmental or conservation-based organizations. Residents who were younger than 25 had difficulty answering questions more suited towards heads of households, while residents employed within local environmental organizations were not representative of the target sample population (residents rather than practitioners). Finally, residents living in Miami for less than a year had less familiarity with the issues discussed in the interview. Snowball sampling methods were used to recruit participants for neighborhoods where residents had not yet been interviewed. We conducted 40 interviews in 2021 from February through July. Participating residents had opportunities to ask questions about the protocol and procedure and received guarantees of confidentiality before giving informed consent. Interviews lasted between 35 and 90 minutes with a median interview time of 49 minutes. Interviews were conducted and recorded using Zoom. Residents were compensated for their time with a gift card.

### *2.3. Survey development*

We used an online survey instrument to understand determinants of adaptation and mobility decisions among a more representative sample of MDC residents. Our online survey integrated insights from (1) the responses from the 40 semi-structured interviews, (2) Protection Motivation Theory (PMT), and (3) community input. Interview responses highlighted considerations for long-term adaptation and mobility within MDC and yielded a wide range of observations relevant to further systematic investigation. We integrated insights from PMT to understand how threat and coping appraisals might affect preferred adaptation or mobility responses, as perceived risk and ability to cope with risks are strong determinants of action. Finally, we held meetings with local decision-makers, community partners, and leaders to solicit input on the types of considerations that should be integrated within the survey. The final

survey was divided into five sections. We assessed: (1) current risk and impacts from SLR and related flooding, (2) financial security, (3) moving history, (4) preferences for adaptation to SLR and related flooding through a decision-making experiment, and (5) demographic information for each respondent. We used Qualtrics survey software (https://www.qualtrics.com/) to host and design the online survey. The survey was available in English and Spanish.

### 2.4. Survey experimental design

Our experimental design required participants to view residential zonal maps that approximated flood depth within their neighborhoods for 1 %-annual-chance flooding and permanent inundation under 0—2 m SLR scenarios before asking respondents to choose among potential adaptation response options. The 1 %-annual-chance flooding scenarios were modeled using the Parallel Raster Inundation Model (PRIMo; Sanders et al., 2022; Sanders and Schubert, 2019; Seeteram et al., 2023). PRIMo is a pluvial, fluvial, and coastal inundation modeling tool designed to predict flood depths and extents across large regions. To represent the modeling domain, PRIMo relies on a fine-resolution grid of topographic elevations and spatially distributed information of landcover types. For Miami-Dade County, we used a 1.5 m resolution digital terrain model (DTM) obtained from aerial laser scanning, which was hydro-conditioned to allow for unimpeded drainage through MDC's network of culverts and canals, and Open Street Map data was used for landcover information (Seeteram et al., 2023). To model the 1 %-annual chance flooding, we used statistical rainfall data from NOAA Atlas 14, 1 % annual exceedance probability stormt surge elevations provided by a 2021 FEMA study, and groundwater elevations obtained from USGS, whereby the storm surge and groundwater elevations are shifted upward by 0–2 m to account for SLR conditions (Seeteram et al., 2023; Sukop et al., 2018; Federal Emergency Management Agency, 2021; Perica S Precipitation). For each SLR scenario 1 % -annual chance flood maps are generated by integrating flood depth from precipitation, groundwater, and storm surges within a composite flood hazard metric. We refer to this flood hazard as "extreme flooding." Permanent inundation flood scenarios were instead generated by applying an equilibrium inundation mapping approach of the mean higher high tide for various SLR scenarios using GIS software (ArcMap, Esri, Redlands, CA). Tidal elevations were combined with groundwater elevations to generate maps of permanent inundation (Seeteram et al., 2023). The procedure used to develop the extreme-flood and the permanent-inundation scenarios for the MDC region is further documented in Seeteram et al. (2023).

Within each scenario-based question, we included context for evaluating the flooding scenario. For inundation scenarios, we asked respondents to consider maps that "show flood depths across Miami-Dade on ***a normal day*** with ***X feet of sea-level rise***" (where *X* was specified for each SLR scenario; Fig. 1). For extreme-flooding scenarios, we asked respondents to consider maps that "show flood

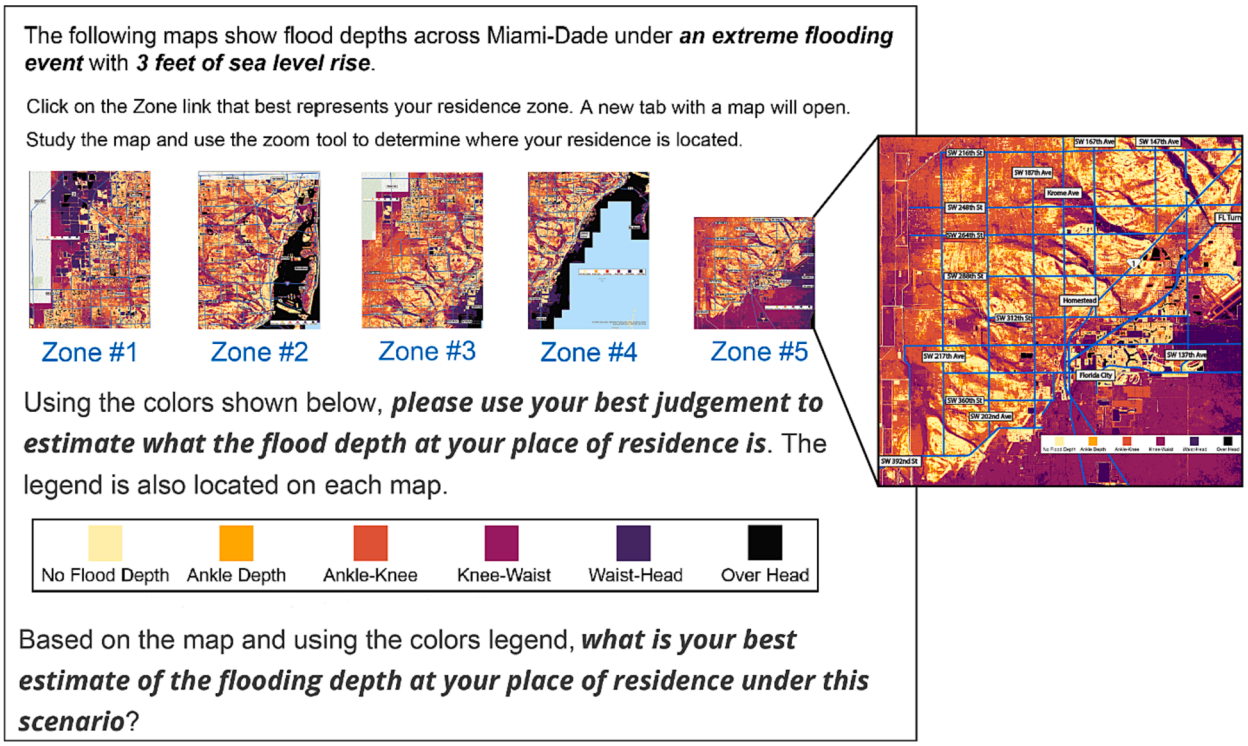


**Fig. 1. Example of scenario-based survey question.** One of the six scenario-based questions is shown as it appeared within the online Qualtrics survey, for a scenario of 3 feet or 1 m SLR with 1 %-annual-chance extreme flooding. All six scenario-based questions included 5 residential zone images with links to further zoom into the maps. The inset map to the right depicts Zone 5 in more detail, under this scenario, with major roads and municipality names highlighted. All flood hazard maps were generated by PRIMo.

depths across Miami-Dade ***under extreme flooding with X feet of sea-level rise***." After viewing each flood scenario, we prompted respondents to indicate whether they would "take no action," "adapt" in place to this level of flooding, or "move" from MDC (SM 2). Respondents who selected a preference for "adapt" were further prompted to select their preferred adaptation option from five choices: (1) purchasing flood insurance, (2) flood-proofing homes, (3) elevating homes, (4) removing/converting septic tank/sewers, (5) or other preferred option (SM 2). Respondents who selected "adapt" or "move" as their response option were also further prompted to indicate whether they would still consider these options without financial incentives or government assistance.

### 2.5. Survey data collection

We used Qualtrics survey panels to recruit participants across the county. The U.S. Census demographics for Miami-Dade County (U.S. Census Quickfacts, 2021) served as the basis for our sampling criteria to ensure a representative sample population. We imposed screening criteria similar to the interviews in that we required each respondent to be a current resident of MDC and have lived in the county for at least one year. However, we lowered the age requirement to 22 years or older to increase the sample size. We piloted the survey in early February 2022. We examined 50 responses, and adjustments were made to the survey to streamline questions and improve data quality. Afterwards, the survey was distributed from March 2022 through April 2022. The median time spent completing the survey was 12 min and 32 s. We collected 597 completed responses.

### 2.6. Analytic approach integrating projections of flood exposure, interviews, and surveys

Interviews and surveys were conducted with the approval of the Institutional Review Board at Florida International University. For the interviews, we used Trint transcription services to transcribe the audio recordings in preparation for analysis. Three researchers assisted with the coding analysis and codebook development. We first used NVivo to inductively identify broad topic areas across all question themes, applying directed qualitative content analysis. Through an iterative process, we developed a codebook for further data categorization. Finally, we created a form using Google forms to extract data across all themes from interviews to facilitate quantitative categorical analysis according to the codebook. For the analysis of survey responses, we used descriptive statistics as well as chi-square analyses to understand relationships between response actions and potential determinants.

We categorized interview and survey respondents within one of four potential climate mobility outcomes—stable, migrating, displaced, and trapped—following an approach similar to Seeteram et al. (2023). First, we determined each interview and survey participant's level of vulnerability. For interview participants, we used self-reported items such as income, financial health before and after the COVID-19 pandemic, and perceptions of financial readiness for future SLR impacts to assess vulnerability. We also considered other social indicators such as race, age, and tenure for a more holistic assessment. These indicators were selected because they aligned

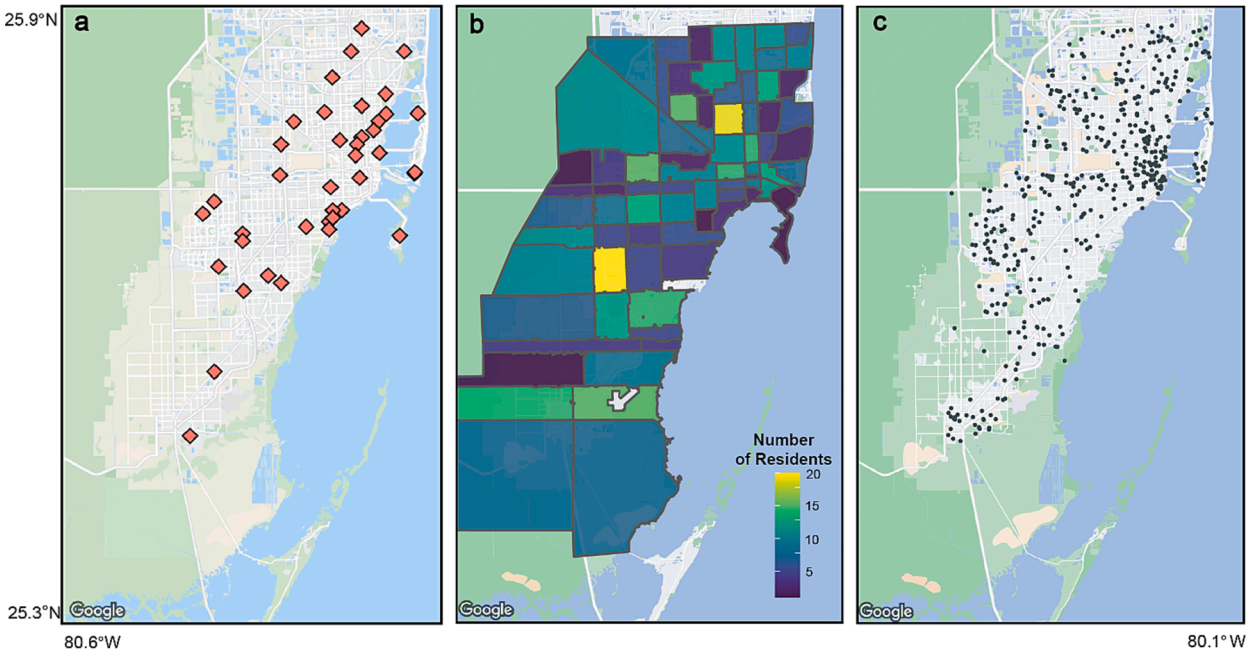


**Fig. 2.** Locations of participating residents and associated demographics. (a) A map of Miami-Dade County, FL, USA, with colored diamonds representing the locations of the home addresses of residents who participated in the interviews ($n$ = 40). (b) A choropleth map of Miami-Dade County, FL, USA, with colors denoting the frequency of participating residents in the survey ($n$ = 597) by zip code. (c) Geolocations for a selection of respondents, who provided their home addresses and are included in the climate mobility assessment ($n$ = 451), are shown here at their place of residence. The basemaps were obtained using the ggmap package (Kahle and Wickham, 2013).

with indicators used in the MDC-specific, flood-relevant social vulnerability assessment in Seeteram et al. (2023). The researchers conducting the coding categorized interviewees as "low vulnerability" or "moderate/high vulnerability" using this information. Two researchers double coded 20 % of the vulnerability determinations using a random sample to assess inter-rater reliability and discussed determinations when disagreements occurred. For survey participants, we created a composite vulnerability indicator from self-reported measures of financial stability such as (1) perceptions of financial security, (2) confidence in financial ability to prepare for flooding, and (3) household monthly income as well as (4) measures of social vulnerability such as race, age, and tenure to align with the social vulnerability assessment of interviewees and indicators from Seeteram et al. (2023). The scores from each item were summed (income was reverse scored to reflect the inverse relationship between higher incomes and social vulnerability), and then averaged. Higher weights were assigned to financial and economic concerns over age, tenure, and race, as financial and economic concerns were observed to be stronger drivers of climate mobility considerations in both the interviews and surveys. This information was available for a subset of survey respondents ($n = 554$). Respondents were then categorized into four vulnerability groups based on these scores: low vulnerability (<the 1st quartile), lower-moderate vulnerability ($\geq 1^{st}$ quartile and < the median), moderate-higher vulnerability (≥the median and < the 3rd quartile), and high vulnerability ($\geq 3^{rd}$ quartile).

We then assessed flood exposure to 1 %-annual-chance flooding from precipitation and storm surge and permanent inundation from groundwater and higher tides under 0–2 m of SLR for participants who reported their home addresses (Fig. 2c). All interview participants ($n = 40$) and most survey participants ($n = 456$) provided their home addresses, which we georeferenced using ESRI World Geocoder in ArcGIS Pro. We then extracted flood depth data across the extreme flooding and permanent inundation flood scenarios for each participant. We considered interview or survey respondents to be flood exposed if they were projected to experience at least 3 cm of inundation or at least 30 cm of flooding (from precipitation or storm surge). We used a larger threshold for precipitation or storm surge driven flooding (30 cm) to be consistent with standards for exposure used by FEMA (FEMA, 2020), whereas we used a lower tolerance for inundation (3 cm) because permanent standing water has significant social, health, and financial impacts to communities (Moftakhari et al., 2018). The model boundaries did not extend to the edge of the northern and western borders of MDC due to insufficient topographic data for flood modeling, and flood depth data could not be extracted for 5 survey respondents and 1 interview participant, reducing the selection to 451 survey and 39 interview respondents. Finally, we created a series of interaction variables that combined flood depths and vulnerability information to categorize residents into mobility categories. Interview and survey respondents of low and lower-moderate vulnerability were included within Stable and Migrating categories and residents of moderate-higher and high vulnerability were included within Displaced and Trapped categories in combination with flood depths that were ≥

**Table 1**
Selected demographic characteristics of the participating residents for both the interviews and surveys as percent of the total sample ($n = 40$ interview; $n = 597$ survey), along with observed counts (number of respondents) for each subcategory, unless otherwise indicated.

| **Demographic** | | **Descriptive Statistics** | |
|---|---|---|---|
| **Age** | ***Interview Reponses*** | **Min:** 19 **Median:** 40.4 **Max:** 76 | |
| | ***Survey Responses*** | **Min:** 22 **Median:** 38 **Max:** 83 | |
| **Years Lived in Miami** | ***Interview Responses*** | **Min:** 0.5 **Median:** 21.5 **Max:**56 | |
| | ***Survey Responses*** | **Min:** 1 **Median:** 22 **Max:**76 | |
| | ***Subcategory*** | ***Interview Responses*** | ***Survey Responses*** |
| **Gender** | Male | 40 %; $n = 16$ | 48.7 %; $n = 290$ |
| | Female | 60 %; $n = 24$ | 50.0 %; $n = 298$ |
| | Non-Binary/Third Gender | | 0.5 %; $n = 3$ |
| | Prefer not to say | | 0.8 %; $n = 5$ |
| **Ethnicity** | Hispanic/Latinx: | 32.5 %; $n = 13$ | 59.4 %; $n = 354$ |
| | Not Hispanic/Latinx: | 65 %; $n = 26$ | 40.6 %; $n = 242$ |
| | Unreported: | 2.5 %; $n = 1$ | |
| **Race** | White/Caucasian | 50 %; $n = 20$ | 62.1 %; $n = 370$ |
| | Black or African American | 37.5 %; $n = 15$ | 23.2 %; $n = 138$ |
| | American Indian/Alaska Native/ Indigenous Latin American | | 1.3 %; $n = 8$ |
| | Asian American | 10 %; $n = 4$ | 1.3 %; $n = 8$ |
| | Native Hawaiian/Pacific Islander | | 0.3 %; $n = 2$ |
| | More than one race | | 3.9 %; $n = 23$ |
| | Other | 2.5 %; $n = 1$ | 7.9 %; $n = 47$ |
| **Tenure** | OwnerRenter | 50 %; $n = 25$ | 39.1 %; $n = 233$ |
| | Living with Family/Friends | 50 %; $n = 25$ | 46.5 %; $n = 277$ |
| | Other | | 12.4 %; $n = 74$ |
| | | | 2.0 %; $n = 12$ |
| | | **Interview Responses** | **Survey Responses** |
| **Annual Household Income** | | Under $52,000: 35%; $n$=14 | Under $54,000: 47.7%; $n$=285 |
| | | $52,000- $70,000: 15%; $n$=6 | $54,001-$72,000; 12.7%; $n$=76 |
| | | $80,000-$100,000: 10%; $n$=4 | $72,001-$120,000: 10.9%; $n$=65 |
| | | $100,000- $150,000: 15%; $n$=6 | $120,001-$180,000: 3.2%; $n$=19 |
| | | $150,000- $200,000: 15%; $n$=6 | $180,001-$240,000: 4.5%; $n$=27 |
| | | Above $250,000: 5%; $n$=2 | More than $240,000: 14.1%; $n$=84 |
| | | Unreported: 5%; $n$=2 | Unreported: 6.9%; $n$=41 |

0.30 m (for precipitation or storm surge-based flooding) or ≥ 0.03 m (inundation). In total, our climate mobility analysis considered 39 interviewees and 421 survey respondents (the total number of respondents for which social vulnerability and flood exposure information was available).

## 3. Results

### 3.1. Sample demographics

Interview and survey respondents represented a diverse geographic distribution of residents living in coastal and inland areas across MDC (Fig. 2a-b) and demographic characteristics Table 1). Interviewees primarily resided in the City of Miami (32.5 %; $n = 13$), Kendall (10 %; $n = 4$) and Unincorporated Miami-Dade (10 %; $n = 4$; SM 3) while survey respondents were represented within each zip code across the county with few exceptions (Fig. 2b). The median age across participating residents was similar for interviewees (40.4 years) and survey respondents (38 years), as well as the median total years lived in MDC (interviews: 21.5 years; surveys: 22 years). Hispanic/Latinx residents were underrepresented within both assessments, with only 32.5 % ($n = 13$) representation in the interviews and 59.4 % ($n = 354$) representation in the surveys compared to 69.4 % of the MDC population that identifies as Hispanic/Latinx (U.S. Census Quickfacts, 2021). The interview sample reflected an even split of residents who were renters and owners, while the survey sample reflected a larger proportion of respondents who were renters (46.5 %; $n = 277$) rather than owners (39.1 %; $n = 233$), which was an underrepresentation of owner-occupied households across MDC (51.6 %; U.S. Census Quickfacts, 2021). Although income could not be directly compared across interview and survey respondents, most respondents in either sample reported household incomes under $54,000, or close to the county median income of $54,000 (Table 1; U.S. Census Quickfacts 2021). Furthermore, most survey respondents reported high-school level (or equivalent) of education (53.9 %; $n = 321$) and residence in a single-family home (50.8 %; $n = 301$).

### 3.2. Threat and coping appraisal and social vulnerability

Interview and survey respondents demonstrated high threat appraisals in their SLR risk perceptions. Respondents displayed substantial concern for the impacts of SLR in MDC, as 82.5 % of interviewees expressed concern ($n = 33$) and most survey respondents (80.9 %; $n = 483$) indicated that they were "very concerned" (40 %; $n = 238$) or "somewhat concerned" (41 %; $n = 266$). Similarly, most survey respondents (59.5 %; $n = 355$) viewed SLR as a current or future risk. Of those survey respondents who did not view SLR as a current risk (36 %; $n = 215$), 41.4 % ($n = 89$) believed SLR will be a future risk.

Around one-third of survey respondents indicated low coping appraisals in response to flooding. We assessed coping appraisal, a component of PMT, through evaluations of financial security and confidence in ability to prepare for future flooding. Most survey respondents (64.2 %) indicated they felt financially secure (29.5 %; $n = 176$) or felt financially secure "most of the time" (34.7 %; $n = 207$). A similar proportion of survey respondents reported they felt "somewhat confident" in their ability to financially prepare for future flooding impacts (67.4 %; $n = 355$), while the proportion of survey respondents who indicated they had "low confidence" in

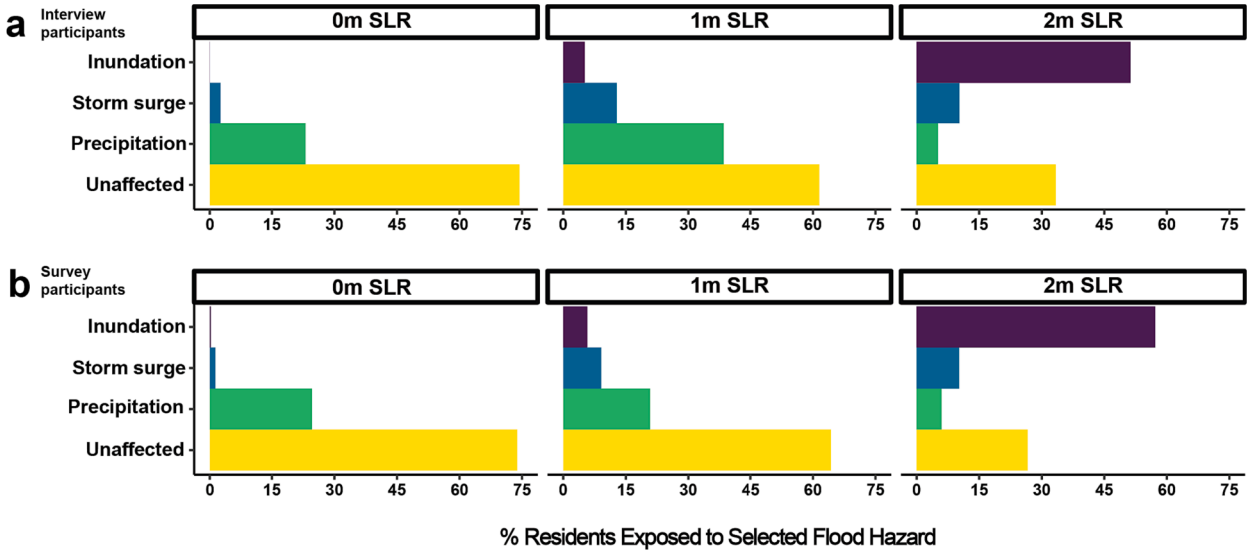


**Fig. 3. Respondent exposure by flood hazard.** (a-b) Each plot shows the percentage of (**a**) interview and (**b**) survey respondents exposed to different types of flood hazards under increasing SLR (*0–2 m SLR*). For each SLR scenario, each resident is characterized as unaffected by flooding (***Unaffected***), inundated at a depth of 3 cm or higher (***Inundation***), or, if neither of those categories, flooded by precipitation (***Precipitation***) or storm surge (***Storm surge***) at a depth of 30 cm or greater (***Precipitation*** or ***Storm surge*** based on whichever is greater depth).

their ability to prepare for flooding impacts (30.4 %; $n = 151$) was comparable to the percent of survey respondents who felt less financially secure (30.5 %; $n = 182$). Overall, our multi-criteria vulnerability assessment for the survey respondents identified 46 % of respondents ($n = 255$) as "low/low moderate vulnerability" and 54 % of respondents ($n = 299$) as "moderate high/ high vulnerability." As for interviewees, prior to the COVID-19 pandemic, 32.5 % of interviewees described themselves as having "good financial health" ($n = 13$), while most interviewees felt "somewhat financially vulnerable" (45 %; $n = 18$) or "financially vulnerable" (22.5 %; $n = 9$). The COVID-19 pandemic resulted in "worsened financial status" for 13 interviewees (32.5 %). These considerations informed the vulnerability assessments in which 62.5 % ($n = 25$) of interviewees were considered "moderate/higher vulnerability" and 37.5 % ($n = 15$) of interviewees considered "low vulnerability."

### 3.3. Modeled flooding impacts

Our analysis of modeled flood exposure highlighted the precipitation-based flooding exposure that residents currently face, and the spatiotemporal shifts associated with exposure to inundation in the long-term (Fig. 3). In the 0 and 1 m SLR scenarios, both interview and survey respondents are largely unaffected. In these scenarios, precipitation is the dominant flood hazard driver affecting upwards of 23 % ($n = 9$; 0 m SLR) and 38.4 % ($n = 15$; 1 m SLR) of interviewees and 24.6 % ($n = 111$; 0 m SLR) and 20.8 % ($n = 94$; 1 m SLR) of survey respondents. At 1 m SLR, storm surge emerges as the dominant driver for a small percent of survey respondents ($n = 41$; 9 %), but overall, both samples of interview and survey respondents reflect higher distributions of inland residents and therefore are not as affected by storm surge (Fig. 2). We also note that reported results in Fig. 3 reflect specific thresholds of flooding (≥0.30 m for

**Table 2**
**Flooding impacts and responses as well as reasons to move from MDC.** Responses to questions and coded responses about flooding impacts, adaptive measures, as well as general plans to move away from MDC are reported below as a percent of total sample (unless otherwise indicated) for both interviews ($n = 40$) and surveys ($n = 597$), with observed counts, $n$.

| | *Description* | *Respondents (n)* | |
|---|---|---|---|
| | ***Flooding related*** | Interviews | Surveys |
| Flooding Experience | Rain* | 75 %; $n = 30$ | 70.4 %; $n = 470$ |
| | Tidal* | 20 %; $n = 8$ | 16.2 %; $n = 97$ |
| | Hurricanes/Tropical Storms** | 35 %; $n = 14$ | 60.1 %; $n = 359$ |
| Flooding impacts | Flooding within neighborhood | 60 %; $n = 24$ | |
| | Flooding within streets/traffic disruption | 50 %; $n = 20$ | |
| | Flooding around housing complex/property | 20 %; $n = 8$ | |
| | Higher property/car insurance premium | 12.5 %; $n = 5$ | 22.3 %; $n = 133$ |
| | Minor damage to your car | 10 %; $n = 4$ | 25.5 %; $n = 152$ |
| | Major damage to vehicle (e.g., engine damage) | 7.5 %; $n = 3$ | 13.2 %; $n = 79$ |
| | Family trapped in home | 5 %; $n = 2$ | |
| | Flooding within home | 2.5 %; $n = 1$ | |
| | Damage to home or property surrounding home | | 26.8 %; $n = 160$ |
| | Damage to other major appliances in home | | 8.2 %; $n = 49$ |
| | Septic tank failure | | 5.9 %; $n = 35$ |
| | Utility disruptions | | 27.3 %; $n = 163$ |
| | Inability to commute to work or school | | 33.7 %; $n = 201$ |
| Adaptive measures | Avoiding areas known to flood | 15 %; $n = 6$ | |
| | Establishing alternate traffic routes | 10 %; $n = 4$ | |
| | Moving cars to elevation | 10 %; $n = 4$ | |
| | Waiting the flood out | 10 %; $n = 4$ | |
| | Purchasing an SUV | 5 %; $n = 2$ | |
| *Mobility* | | | |
| Would live in MDC for rest of life (*conditions permitting*) | Yes | | 66.0 %; $n = 371$ |
| | No | | 16.2 %; $n = 91$ |
| | Unsure | | 24.0 %; $n = 135$ |
| Considering moving now or in next few years | Yes | 47.5 %; $n = 19$ | 40.7 %; $n = 243$ |
| | No | 35 %; $n = 14$ | 38 %; $n = 227$ |
| | Unsure | 17.5 %; $n = 7$ | 21.3 %; $n = 127$ |
| (*If yes*) | Affordability | 17.5 %; $n = 7$ | 72.8 %; $n = 177$ |
| Reasons stated for moving from Miami-Dade | Crime | 2.5 %; $n = 1$ | 32.9 %; $n = 80$ |
| | Education | | 15.2 %; $n = 37$ |
| | Employment | 22.5 %; $n = 9$ | 26.7 %; $n = 65$ |
| | Family | 10.0 %; $n = 4$ | 17.7 %; $n = 43$ |
| | Increased Heat | 5 %; $n = 2$ | 10.3 %; $n = 25$ |
| | Lack of Public Transport | 2.5 %; $n = 1$ | 9.5 %; $n = 23$ |
| | Monthly rent increase too high | | 37.0 %; $n = 90$ |
| | More space needed | | 23.0 %; $n = 56$ |
| | Retirement | 7.5 %; $n = 3$ | 7.8 %; $n = 19$ |
| | Flooding | 20 %; $n = 8$ | 18.9 %; $n = 46$ |
| | Too crowded | 12.5 %; $n = 5$ | 25.5 %; $n = 62$ |
| | Traffic | | 35.4 %; $n = 86$ |

* flooding experience reported from 2016- early 2021, ** flooding experience reported from 2012- early 2022.

precipitation and storm surge and ≥ 0.03 cm for inundation). However, experiences of precipitation-based flooding may be higher among respondents as flooding is occurring at depths lower than this threshold (SM 4). However, as SLR increases to 2 m, inundation driven by groundwater and higher tides replaced precipitation-based flooding as the dominant flood driver, affecting 51.3 % ($n = 20$) of interviewees and 57.2 % ($n = 258$) of survey respondents and highlighting a long-term driver of climate mobility (Fig. 3).

### 3.4. Reported flooding impacts and adaptive responses

Respondents reported widespread precipitation-based flooding events across the county, prompting ad-hoc adaptations at the individual scale. Most survey respondents (70.4 %; $n = 470$) reported experiences of rainfall-related flooding over a period of five years (from 2017 through early 2022, Table 2), and we observed a similar proportion of interviewees (75 %; $n = 30$) who reported experiences of rainfall-related flooding over a similar time frame (2016 to early 2021: SM 5). This observation aligned with our modeled results for interview and survey respondents, where precipitation drives most of flooding observed in the 0 m and 1 m SLR scenarios (Fig. 3 and SM 4). Respondents within both samples reported experiencing tidal flooding at similar rates (interviews: 20 %, $n = 8$; surveys:16.2 %, $n = 97$; Table 2). About 10 % of all survey respondents ($n = 60$) and three interviewees (7.5 %) reported experiencing flooding from all three sources. Incidentally, all three interviewees who reported flooding experiences from rain, high-tides, and hurricanes also lived along canals across the county and indicated that they observed "fish in the street" during or after the flooding. As a resident of Doral explained:

> "Most recently, like one year ago, there was a full moon, there was a high tide and it just rained, and the water flowed down the streets for blocks and blocks and blocks…I had to park my car somewhere else, I had to call out of work because it didn't drain the next morning. It stayed like that for like over 48 hours. You could see, like, fish going through the streets of Doral Boulevard that had come up from the canals."

Although only one interviewee described missing work due to flooding, one-third of survey respondents ($n = 201$) indicated they had missed work or school as a financial impact of flooding (Table 2). Respondents also expressed other severe impacts of flooding (Table 2), including major damage to vehicles, such as engine damage (interviews: 7.5 %, $n = 3$; surveys: 17.2 %, $n = 79$), utility disruptions (surveys: 35.5 %, $n = 163$), and damage to home or property surrounding home (surveys: 34.9 %, $n = 160$). Respondents also reported less severe impacts such as flooding within streets that caused traffic disruptions (interviews: 50 %, $n = 20$) and minor damage to vehicles (interviews:10 %, $n = 4$; surveys: 33.1 %, $n = 152$) with greater frequency. To avoid flooding, respondents adapted by avoiding flooding after rain events (interviews:15 %, $n = 6$), establishing alternate routes for destinations (interviews:10 %, $n = 4$), or simply waiting the flood out (interviews:10 %, $n = 4$), amongst other measures (Table 2). The following quote illustrates the flood depths experienced across the county prompting these types of adaptations. One resident of Kendall, a suburb of Miami, remarked:

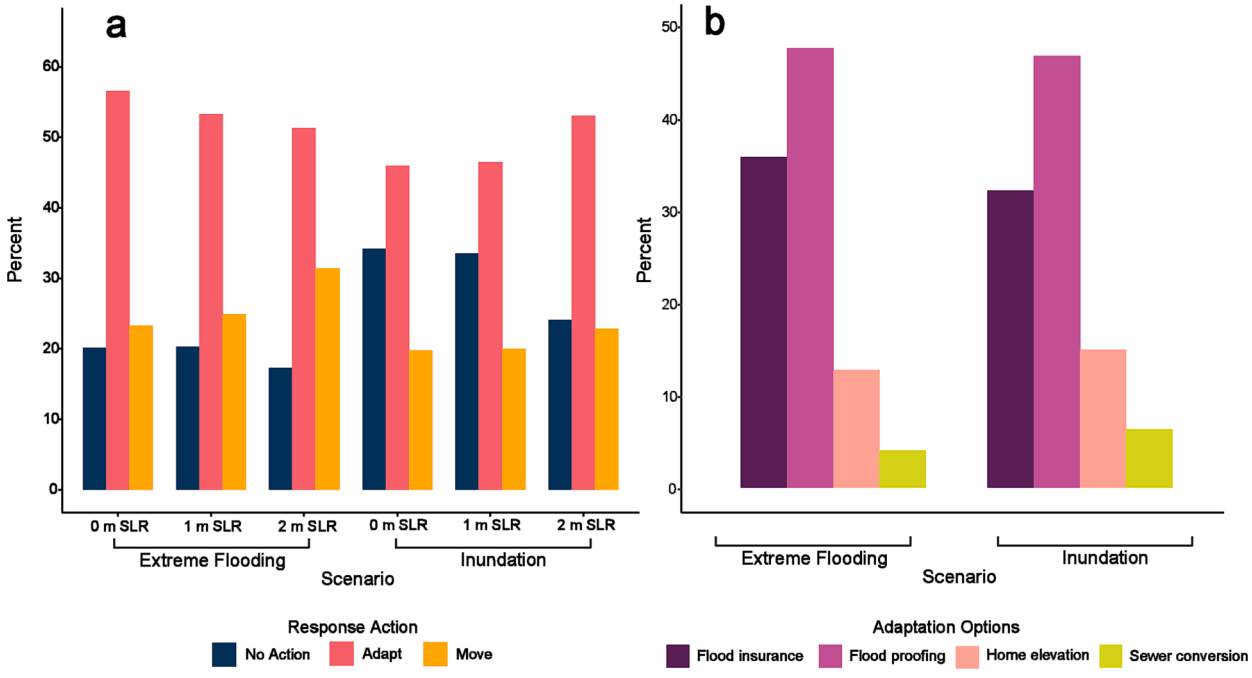


**Fig. 4. Response action and adaptation option selection by SLR scenario among survey responses.** ***(a)*** Response actions chosen by survey participants are shown for increasing SLR scenarios for extreme flooding (1 %-annual-chance flooding from either precipitation, storm surge, or groundwater) and inundation (SLR alone) flood simulations. ***(b)*** Preferences for adaptation options are shown for survey respondents who chose "adapt" within any extreme flooding ($n = 299$) or any inundation flooding scenario ($n = 255$).

"I mean, you have these huge puddles of water that are incredibly deep and it's impossible to drive your car through them depending on the area. If you go anywhere close to downtown, it's like you're waiting for a river of water, just to disappear before being able to get anywhere."

### 3.5. Climate mobility within Miami-Dade County

Respondents often expressed desires to move from Miami-Dade County, of which climate concerns were one of many contributing factors. Many survey respondents (40.7 %; $n = 243$) indicated they were considering leaving MDC, but a comparable, yet slightly lower proportion of survey respondents (38 %; $n = 227$) indicated that they had "no plans" or were "not considering" moving from MDC within the next few years (Table 2). We also observed a similar trend among interviewees, where 47.5 % of respondents indicated they were considering planning to move ($n = 19$), and 35 % ($n = 14$) of interviewees did not express an interest in moving. For these respondents who indicated they are considering or planning to move, affordability (interviews:17.5 %, $n = 7$; surveys: 72.8 %, $n = 177$) followed by monthly rent increases (surveys:37 %; $n = 90$) and increased traffic (surveys: 35.4 %; $n = 86$) were the top cited reasons for these considerations (Table 2). Interview and survey respondents indicated that flooding (interviews: 20 %, $n = 8$; surveys: 18.9 %, $n = 46$) and increased heat (interviews: 5 %, $n = 2$; surveys: 10.3 %, $n = 25$) were also reasons they were considering or planning to move from MDC. However, the preference to stay in MDC is strong; two-thirds (66 %; $n = 371$) of survey respondents indicated they would consider living in MDC for the rest of their lives, conditions permitting (Table 2). In a couple of instances where interviewees were very aware of their personal flood risk ($n = 2$), the desire to stay in MDC superseded the financial risk associated with staying in MDC. One resident remarked,

**Table 3**
**Reasons to move or stay by category of direct/indirect sea-level rise risks relevant to climate mobility.** Reasons interviewees stated for moving from or staying in Miami-Dade County are indicated by climate mobility category with illustrative quotes. Observed counts ($n$) are provided for the number of interviews themes were recorded across.

| *Climate Mobility Category* | *Reasons to Move (Number of Interviews)* | *Reasons to Stay (Number of Interviews)* |
|---|---|---|
| Stable | **Impacts to neighborhood ($n = 2$)**<br>"I think if there were… increased impacts to our neighborhood or even to Miami to a significant…where it would be changing kind of the culture, the nature of Miami, I would absolutely consider that. | **Feelings of safety ($n = 2$)**<br>"We were tuned in [to sea level rise] even back in 2009, 2010… mainly because my brother had lived in the Grove for 30, 40 years and he had told us, *'You want to be up on the Coral Ridge. That's where we want to be.*' And that's where we are." |
| | **If necessary ($n = 2$)**<br>"Oh. I mean, I hope it never gets to that, but if it's something that it makes sense to move when it's for the well-being of me and my family, then yes, I would move, but I would rather not." | **Family ($n = 2$)**<br>"My wife and I have talked about in the past like, 'Oh, let's move on', but we never went past the serious phase of thinking about it, because in the end, family always keeps us over here." |
| Migrating | **Financial necessity ($n = 4$)**<br>"We need to eventually move soon because the values of the houses are going to drop because of climate change." | **Not relevant to inland communities ($n = 2$)**<br>"Not for sea level rise, because I still don't see sea level rise affecting suburbs just yet." |
| | **Easier to leave (renters only; $n = 2$)**<br>"I mean, that's why I don't I haven't bought [a property]. The idea of being able to sort of make a clean break if I need to. It is appealing. And you cannot do it easily with home ownership." | |
| Displaced | **Excessive flooding prompting move ($n = 7$)**<br>"I definitely could foresee us moving if there's enough damage, and that's the only solution, the only choice." | **Safe ($n = 1$)**<br>"Because I feel this area here is safe from them because we're far in from the water itself" |
| | **Affordability ($n = 3$)**<br>"I mean, yeah, if I can't afford to stay here, you know, I wouldn't have a choice but to move." | |
| Trapped | **Excessive flooding prompting move ($n = 5$)**<br>"If sea-level rises and there's a lot of damage, that is too much to repair for me or if my landlord basically decides that it's not worth it… to fix it…you know, I'm going to have to move anyways." | **Age ($n = 1$)**<br>"I don't think so [I won't move], not at my age" |
| | **Avoiding experiencing future impacts ($n = 3$)**<br>"I've seen other areas of Miami be affected by sea level rise, and that's not something I want to deal with." | |
| | **Flooding among primary reasons for moving ($n = 3$)**<br>"I've lived these horrible events in the last two years that make me have a more pessimistic or a more sense of urgency" | |

"I don't care about the money. I'm just going to ride it out and keep enjoying watching sunsets on the bay and keep kayaking and having the quality of life, which I cannot do anywhere else with that amount of ease."

Overall, interviewees demonstrated a high willingness to move in response to future SLR impacts (Table 2 and Fig. 4). 75 % of interviewees ($n = 30$) affirmed they would move in the future because of SLR, 22 % of interviewees ($n = 9$) said "no," and 1 resident was unsure. Differences in tenure did not appear to influence decision-making with an almost equal split in renters and owners who indicated they would move (37.5 % of renters and owners; $n = 15$ each) in response to future SLR versus those who would not (renters:12.5 %; $n = 5$; owners: 10 %; $n = 4$). Some residents indicated certain "tipping points" or events or signals that would prompt them to consider moving. 20 % of interviewees ($n = 8$) cited experiencing a future catastrophic hurricane, akin to Hurricane Andrew (1992; 9 interviewees lived in MDC during Hurricane Andrew), as well as increased flooding (interviews:20 %; $n = 8$), signs that the structural integrity of home or surrounding infrastructure was compromised (interviews:17.5 %; $n = 7$), and flooding impacting the home (interviews:10 %; $n = 4$) as potential tipping points (Table 2). A few interviewees also indicated certain signals or interventions that, were they to occur, could persuade them to stay in MDC. These interventions included drainage improvements (interviews:15 %; $n = 6$), clear and unambiguous communication from elected officials on adaptation planning (interviews:10 %; $n = 4$), and economic restructuring (interviews:7.5 %; $n = 3$; Table 2).

Survey respondents, however, overwhelmingly preferred to "adapt" in place in response to flooding from SLR, though the preference for moving away marginally increased as flooding exposure projections increased (Fig. 4a). Survey respondents' preferences for adaptation decline slightly within the extreme flooding scenarios as SLR increases (56.6 % to 51.3 % favorability; Fig. 4a) and increase slightly as SLR increases within the inundation flooding scenarios (46 % to 53.1 % favorability; Fig. 4a). Respondents who chose "adapt" ($n = 299$ respondents, extreme flooding scenarios; $n = 255$, inundation scenarios) favored smaller scale adaptive measures such as flood proofing homes (46.7 % and 47.5 % favorability) or purchasing flood insurance (35.3 % and 35.8 % favorability) over larger-scale household measures such as home elevation (12.7 % and 14.9 % favorability) or sewer conversion (4 % and 6.3 % favorability) across both flood hazard types and increasing SLR scenarios (Fig. 4b). Follow-up questions about whether respondents would still consider these options if no financial or government incentives were offered did not deter most respondents from their chosen option.

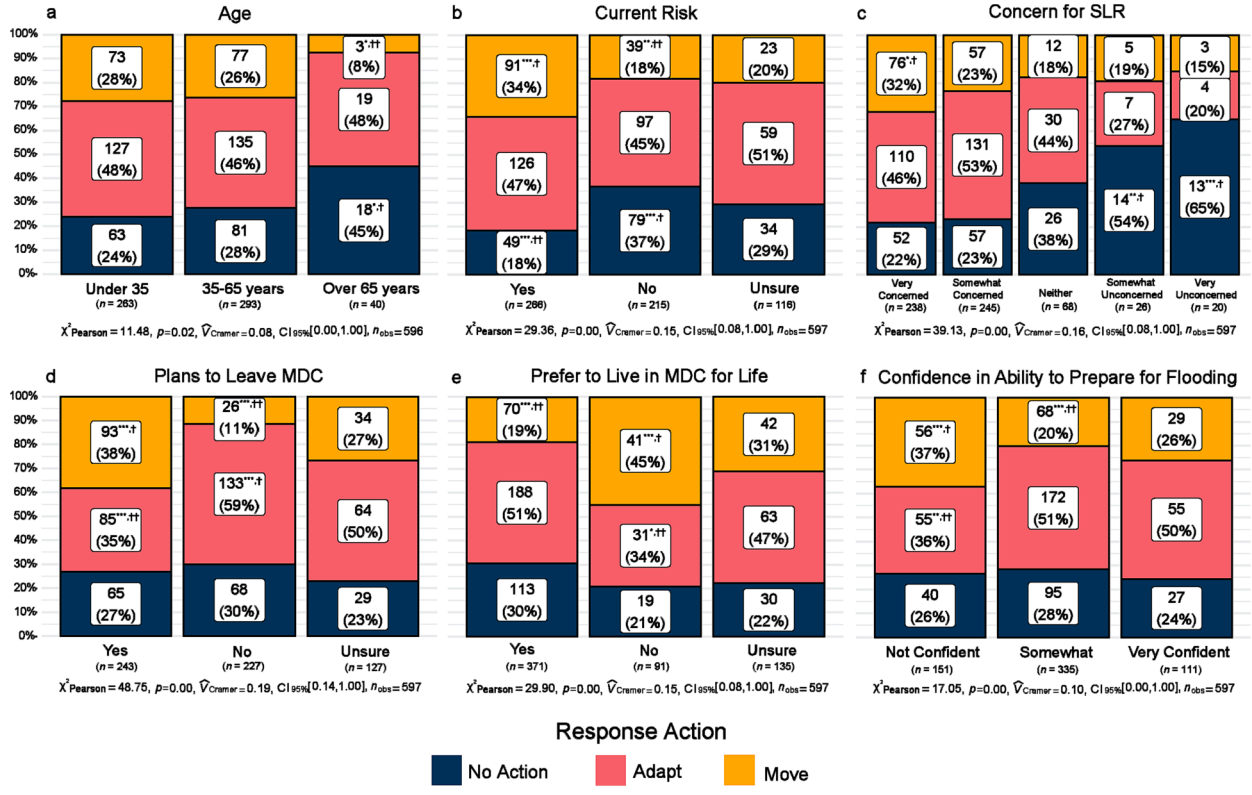


**Fig. 5. Chi- Sq tests of independence results for selected indicators and response decisions among survey respondents.** (***a-f***) Bar charts show response decisions (*take no action, adapt, or move*) from survey respondents for selected indicators where $p < 0.01$, $p < 0.05$, or $p < 0.1$ after chi-square tests for independence. Observed counts ($n$) and percentages are shown for each subcategory within indicators. Statistically significant results are shown by subcategory after post-hoc analysis of the standardized residuals. *** denotes $p < 0.01$, ** denotes $p < 0.05$, and * denotes $p < 0.10$ after chi-sq tests of independence. † denotes a positive relationship with the response action and ††denotes a negative relationship with the response action.

### 3.6. Determinants of climate mobility responses

The assessment of potential climate mobility pressures across respondents using modeled flood depths and social vulnerability assessments was consistent with increasing flood exposure through time, whereby residents initially categorized as Stable (interviews: 28.2 %; $n = 11$; surveys: 32.3 %; $n = 136$) or Displaced (interviews: 46.2 %; $n = 18$; surveys: 41.2 %; $n = 175$) under conditions of low SLR (0 m SLR) are recategorized into Migrating (interviews: 25.6 %; $n = 10$; surveys: 30.4 %; $n = 128$) or Trapped (interviews: 46 %; $n = 16$; surveys: 43.2 %; $n = 182$) outcomes under intensifying flood risk (2 m SLR: SM 5). Interviewees overwhelmingly expressed their willingness to move if SLR worsens overtime, though the mobility pressures differ across climate mobility categorizations (Table 3). Since residents often shift into different mobility categories through time, we selected and organized residents' perspectives based on whether they were classified as Migrating or Trapped under 0 m and 1 m (*greatest direct risk*) or Stable and Displaced under 2 m (*greatest indirect risk*) under either SLR flood hazard scenario (Table 3). Overall, views and pressures expressed among interviewees aligned with the conceptual framework from Seeteram et al. (2023). Interviewees classified as Stable reflected less immediate concerns for future climate-related mobility. Stable respondents indicated they planned to move only "if necessary" (5 %; $n = 2$) or if they felt indirect "impacts to their neighborhood" emerged (5 %; $n = 2$; Table 3). Within the Migrating category, tenure played a role in shaping fears about moving or staying in MDC. Interviewees who were property owners expressed a more immediate need to move for financial reasons (7.5 %; $n = 3$), while renters expressed flexibility in their ability to move (5 %; $n = 2$) because they are not tethered to a financial asset (Table 3). Interviewees classified as Displaced cited moving out of necessity (17.5 %; $n = 7$), which is less consistent with the mobility framing's emphasis on indirect risks, although a few respondents cited affordability reasons (7.5 %; $n = 3$) for moving (Table 3). Interviewees classified as Trapped also indicated that excessive flooding damage to their homes would result in mobility pressure (12.5 %; $n = 5$), and a few interviewees (7.5 %; $n = 3$) indicated that current levels of flooding have contributed to a sense of urgency for moving. Some Trapped respondents (7.5 %; $n = 3$) also cited excessive impacts being experienced elsewhere and indicated they wanted to avoid future impacts (Table 3). Interviewees who indicated they would not leave MDC across mobility categorizations cited feelings of safety (10 %; $n = 4$), family (5 %; $n = 2$), and age (2.5 %; $n = 1$; Table 3).

Among survey respondents, we did not observe consistent or statistically significant patterns among preferred response actions for respondents sorted into any of the climate mobility categories, but chi-square analyses revealed a few determinants of climate mobility. Age, plans to move from Miami-Dade in the near-term, as well as high threat and low coping appraisals strongly influenced chosen response decisions among survey respondents (Fig. 5). Residual analyses indicate that survey respondents 65 years or older ($n = 40$) were positively associated ($p < 0.1$) with the "take no action" response and conversely negatively associated ($p < 0.1$) with the "move" response (Fig. 5a). Survey respondents who planned to leave MDC ($n = 243$) were positively associated ($p < 0.01$) with "move" responses while respondents who are not planning on moving ($n = 224$) were negatively associated ($p < 0.01$) with "move" responses and instead positively associated ($p < 0.01$) with "adapt" responses (Fig. 5d). Likewise, respondents who indicated they prefer to live in Miami ($n = 371$) were negatively associated ($p < 0.01$) with "move" responses (Fig. 5e). Measures of PMT, such as concern for SLR, risk perception (threat appraisal), and confidence in financial ability (coping appraisal), also were strongly associated with response actions. Respondents who did not perceive SLR to be a current risk ($n = 215$; Fig. 5b), as well as those who were unconcerned about SLR ($n = 20$; Fig. 5c), had strong, positive associations ($p < 0.01$) with the "take no action" response. Similarly, respondents who did

**Table 4**
**Additional concerns raised about SLR impacts and adaptation among interviewees.** Themes relevant to SLR impacts or adaptation that emerged across the interviews are shown below with illustrative quotes for context. Observed counts ($n$) are provided for the number of interviews themes were recorded across.

| Resident Concerns | Illustrative Quotes |
|---|---|
| Affordability ($n = 5$) | "You kind of feel, I think, **trapped**, you know, like nowhere to go. So that's why I'm trying to make my move going up further north, because it's in that area they're still developing where I want to move… There's a lot more room to kind of move around and feel like, 'ok there is flooding here, maybe I can move elsewhere without there being a big issue'. But here it's trapped, especially with there being the affordable housing issue and everything." – *Resident of Opa-Locka* |
| Gentrification /Higher Elevation | **Gentrification ($n = 7$)**<br>"People are afraid of sea level rise. So, you know, I think that's a direct impact of why developers are looking to move into our neighborhoods." –*Resident of Allapattah*<br><br>**Elevation ($n = 7$)**<br>"It [elevation] was a very heavy factor, yes. Both of our units are well above mean sea level. The other [property] is probably 15 feet above. This [property] is close to 17 feet above sea level." –*Resident of Coconut Grove* |
| Investments | **High risk investments ($n = 4$)**<br>"My husband at some point said, 'oh, let's buy an apartment in Miami Beach, and I said, absolutely not'. Why would we buy in a place where we know that that water levels are an issue? So that was an absolute no to me." –*Resident of Coral Gables*<br><br>**First-time home buyer caution ($n = 7$)**<br>"My wife and I, we're looking at buying property some time and we looked at our budget and everything…But then we saw how the flooding was taking place. It just made no sense for us to invest in something down here. So, if there is going to be an investment it needs to be further north." – *Resident of Palmetto Bay* |
| Senior Issues ($n = 3$) | "I mean, that water is high, not low. I don't care too much for walking in that because …because you know a pole could be down, you know electricity could be in there. That has me worried. I can't trust the walk out… But if [there] was flooding, where I can't see one foot in front of the other. Yeah. I'm going to have to take a leap of faith." – *Resident of Coconut Grove* |

perceive SLR to be a current risk ($n = 266$) had strong, positive associations ($p < 0.01$) with "move" responses and strong, negative associations ($p < 0.01$) with the "take no action" response. Finally, respondents who indicated they are not confident in their financial ability to prepare for flooding ($n = 151$) had strong, positive associations ($p < 0.01$) with the "move" decision. We did not find that differences in tenure had a statistically significant impact on chosen response actions, which is consistent with observations from the interviews. Although statistically significant, the $\widehat{V}$ was $< 0.20$ for all the reported residuals, indicating weak associations between each of the featured categorical variables in Fig. 5 and the response actions.

### 3.7. Additional concerns raised -about SLR impacts and adaptation

Respondents also expressed concerns about other SLR related impacts that interact with adaptation decisions including affordability, gentrification, investments, and issues specific to seniors (Table 4). Most survey respondents, 64 % ($n = 381$), selected the "ability to find safe, affordable housing," followed by the "ability to maintain their employment/business in MDC" (surveys: 37.6 %; $n = 224$) and the "desire to stay with family and friends" (surveys: 36.5 %; $n = 217$) as important within their chosen response action. Chi-square tests of independence indicated statistical significance and positive associations between respondents who chose the "ability to find safe, affordable housing" and the decision to "move" ($\chi^2 = 63.6$, $p < 0.05$). Interviewees expressed concerns about flooding impacts that when coupled with reduced affordable housing options create a "trapped" feeling (Table 4). Ongoing gentrification issues were also a concern to interviewees living in higher elevated and historically under-invested areas regardless of whether they attributed this phenomenon to rising seas. While attributing SLR to ongoing gentrification remains challenging, interviewees (17.5 %; $n = 7$) expressed that elevation did factor into their decision to purchase property or will be a factor in their future decisions (Table 4). Furthermore, first-time home buyers (interviews:17.5 %; $n = 7$) expressed caution about buying in MDC because of the flooding and affordability issues, and other interviewees (10 %; $n = 4$) also expressed their hesitancy in buying property in known high-risk areas (Table 4). Finally, the vulnerability of seniors, especially those that are lower income, who rely more on walking and public transportation and have critical care needs (interviews:7.5 %; $n = 3$) were highlighted, as repeated and higher flood depths pose accessibility challenges (Table 4).

### 3.8. Potential relocation destinations

Respondents preferred destination cities within the state of Florida if they had to move (Fig. 6). Survey respondents indicated a preferred relocation destination in response to SLR ($n = 505$) regardless of whether they selected "move" as a response option. Orlando, FL (interviews:12.5 %, $n = 5$; survey: 34.1 %, $n = 172$), North Florida (interviews:5%, $n = 2$; survey: 29.7 %, $n = 150$), and Broward County, FL (interviews: 15 %, $n = 6$; survey: 22.6 %, $n = 114$), were the top three destinations selected (Fig. 6). Outside of Florida, survey respondents indicated Atlanta, GA (19.4 %; $n = 98$), North Carolina (15.6 %; $n = 79$), and South Carolina (11.5 %; $n = 58$) as top three destinations. Few respondents selected destinations outside of the U.S. Southeast (Fig. 6).

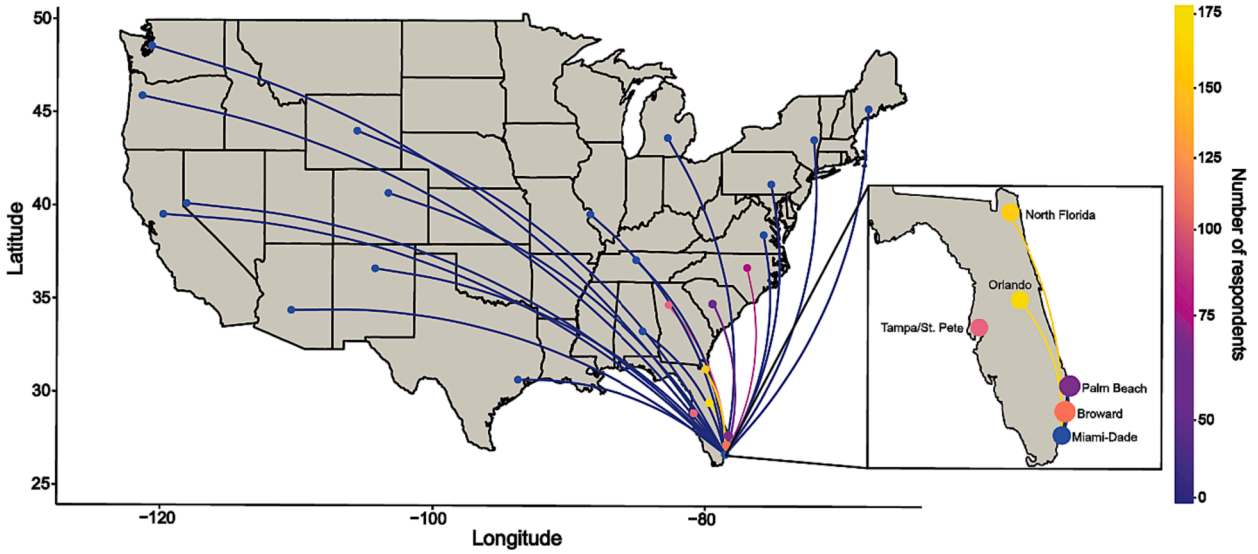


**Fig. 6. Map of potential migration destinations according to survey responses.** Reported migration destinations are shown for respondents who indicated a potential location to which they would relocate as a result of SLR impacts. Colors for points and lines represent the number of respondents who indicated the location as a preference.

## 4. Discussion

Our assessment of climate mobility and adaptation preferences among MDC residents is novel in its integration of interviews, surveys, and SLR-flood exposure models and reveals the disparities among emerging flooding conditions, preferred adaptation choices, mobility considerations, and transformations needed to counter dynamic SLR risk. Among interviewees, financial and economic pressures highly influenced differential climate mobility pressures suggesting that climate mobility outcomes may exacerbate social inequalities through time. Higher preferences for in-situ adaptations, even under high SLR scenarios, among the broader Miami-Dade public may further compound this potential reality, as managing flood and inundation risks may be insufficient over time. As SLR risks intensify, long-term financing, social conflicts, and inadequate governance structures present limits to adaptation (Hinkel et al., 2018), and certain residents may need to consider relocation sooner. We offer a few considerations in light of these results below.

Sea-level rise and related flooding are reshaping mobility decisions now, supporting a model of climate mobility consistent with Boas et al. (2022). Among interviewees, 20 % of survey respondents and several interviewees indicated that SLR was a current consideration in their decision to leave MDC and indicated that repetitive and disruptive flooding from rainfall events influenced their decision. As might be anticipated based on prior research (Adger et al., 2021; Boas et al., 2022; Cundill et al., 2021; Wiegel et al., 2019), both interview and survey respondents cited flooding impacts in combination with other motivators such as affordability, education, and retirement in their plans/considerations to move. Statistically significant, yet weak associations between indicators, such as threat and coping appraisals, and respondent choices within the flooding scenario-based questions highlight the complexity of these decisions and suggest other determinants may be more influential in mobility choices. SLR-related flooding is emerging as a consideration within more permanent and deliberate mobility decisions, but it is likely to be one of many considerations. This finding is consistent with observed higher intentions to move as SLR accelerates within South Florida (Treuer et al., 2018). However, we note that MDC's population grew 6.7 % and the state of Florida's population grew 16.1 % over the past decade (2010–2021; U.S. Census, 2021). While these decision dynamics will continue as flooding impacts persist, they will likely continue at smaller scales until flooding is more fully internalized within economic decision-making, perhaps as flood risk information is made readily available (Hino and Burke, 2021).

We documented frequent and geographically extensive pluvial floods, and even non-extreme compound floods, that are triggering decisions to move now, which is a novel expansion in our understanding of the types of climate risks that should be considered as drivers of mobility and modeled accordingly. Up to 75 % of both sets of respondents experienced flooding over the years 2016 through early 2022, driven primarily by rainfall-related flooding. The modeled results support resident observations, where precipitation drives much of the 1 %-annual-chance flooding in the 0 and 1 m scenarios, and regional case studies (Peña et al., 2022; Sukop et al., 2018) also emphasize the future flood risk from precipitation and groundwater (and their interaction) in MDC. Assessments of SLR risk or migration primarily focus on inundation or 1 %-annual-chance flooding (Hauer et al., 2016; Hauer et al., 2021b) as drivers of mobility, and not smaller, more frequent flood hazards and inundation, which over time may contribute to mobility. Recent studies highlight the underestimation of urban flood risk and the need to develop models that more accurately consider these risks (Rosenzweig et al., 2021; Sanders et al., 2022). Integrating urban flood risks within regional climate adaptation planning is especially important, given the complexities of the built environment, its interaction with stormwater management infrastructure, and temporalities associated with evolving development patterns and infrastructure performance.

The emerging impacts of pluvial flooding highlight "new normal" conditions for residents across Miami-Dade County who are now "living with water." Interviewees described current ad-hoc adaptations in response to higher frequency of flooding events across the county and discussed impacts of non-extreme compound flooding events (combined precipitation and tidal flooding). One-third of survey respondents reported experiencing an inability to attend work or school due to flooding. These occurrences are likely to increase, especially for residents living along canals, due to new normal flooding conditions given the overlap between the seasonality of higher-tides and heavy rainfall events in South Florida (Mach et al., 2022). Interviewees highlighted the prevalence of flooding-related traffic impacts, and recent studies in other coastal areas suggest that these impacts will continue (Hauer et al., 2021c; Kasmalkar et al., 2020). Regions with few public transportation options and high reliance on vehicles for transportation, like MDC, are likely to continue experiencing growing rates of missed work and school days as residents, especially less wealthy residents, are unwilling to drive through floodwaters and risk serious vehicle damage. Regional planning, except for the South Florida Water Management District (SFWMD, 2021) to our knowledge, has not fully considered the impacts of chronic pluvial flooding, which may reshape the types of interventions needed. More frequent heavy rainfall could place significant demand on aging infrastructure (University of Maryland and Texas A&M University, 2018) and curtail economic activity. Hino et al. (2019) considered the economic impact of high-tide flooding, but more research is needed to understand the regional economic impacts of pluvial flooding. Extreme precipitation events are likely to increase under scenarios of medium and high emissions pathways globally (Thackeray et al., 2022), indicating an emerging research gap in our understanding of potential regional impacts, including climate mobility.

Socioeconomic pressures heavily influenced the differential climate mobility outcomes described by interviewees, underscoring how future climate mobility could result in unequal futures without strategic interventions. Generally, respondents expressed climate mobility pressures that aligned with the conceptualization in Seeteram et al. (2023). Wealthier interviewees in Stable and Migrating categorizations displayed higher levels of adaptive capacity, which granted more flexibility within their decision considerations (Adams and Kay, 2019; Mortreux and Barnett, 2017). Interviewees categorized as Stable generally refrained from expressions of moving in the future due to SLR, unless they felt directly impacted or some occurrence necessitated it. Property owners categorized as Migrating expressed fears of being "trapped" with depreciating assets and an uncertain financial future, while renters within this category expressed more freedom in mobility choices because they are not tethered to an asset. Interviewees facing direct flood exposure (Migrating or Trapped) described threading a delicate balance between their immediate desire to remain in MDC with their

concerns for future impacts. However, as flood risk information becomes more available, these residents could face a market with fewer buyers (Hino and Burke, 2021), as indicated by other interviewees who were cautious about high-risk investments within MDC.

Lack of affordable and safe housing options, severe property damage, and asset devaluation were identified as financial and economic pathways, which in combination with flooding impacts, could leave residents "trapped" over time. Over 60 % of survey respondents indicated the ability to maintain safe, affordable housing was influential in their response decision, and respondents who indicated this priority were more associated with responses to move away. Relocation destinations within Florida were highly preferred, including metropolitan areas like Orlando, FL, an outcome modeled by Hauer (2017), as well as the Tampa/St. Petersburg area. However, low housing affordability in both the Orlando and Tampa/St. Petersburg areas is a serious concern for current residents (Xu and Hale, 2022). If climate mobility trends continue and the state-wide affordable housing stock remains low, residents could be "trapped" by both increasing flooding exposure and lack of affordable, safe destinations. Furthermore, high costs of disaster-related damage undermine residents' ability to recover from severe flooding damage, which may also prompt relocation. Contrary to the conceptualization of Displaced communities in Seeteram et al. (2023), interviewees categorized as Displaced and Trapped both described situations where moving would be "a necessity" because repairs would not be financially feasible. Survey respondents who reported less confidence in their ability to prepare for increased flooding impacts were more strongly associated with responses to move away, raising climate justice concerns. Purchasing flood insurance to alleviate the costs of repairs may not remain an option in the long term if flood exposure intensifies and damages exceed individual capacities (Wilson et al., 2020).

Finally, higher preferences for in-situ adaptation options persisted across SLR scenarios, highlighting the need for long-term, society-wide adaptation and raising concerns about which communities may struggle to adequately respond as impacts and adaptation costs intensify. Although preferences for moving increased overall under both 2 m SLR scenarios, preferences for moving did not exceed 37.9 % favorability under either SLR flood hazard scenario. Instead, most survey respondents expressed a strong desire to "adapt" in place and chose more affordable, smaller-scale adaptation options. This outcome is aligned with Treuer et al. (2018)'s observation of higher support for adaptation bonds within South Florida under lower SLR scenarios and higher preferences for moving as SLR accelerates, as well as PMT which posits that people will choose risk mitigation options they perceive to be effective and can carry out themselves (Aerts, 2020; Bubeck et al., 2018). However, in-situ adaptation will likely be insufficient in the face of accelerating risk without strategic societal transformations. As exposure to SLR flood risks increases throughout the century, adaptation costs will rise as greater proportions of current and future populations, land, and infrastructure require protection (Haasnoot et al., 2021; Hinkel et al., 2018, 2014). Hence, a society-wide commitment to adaptation is needed as individuals alone cannot counter cascading and escalating impacts. Otherwise, Seeteram et al. (2023) estimates up to 68 % of current MDC residents may be trapped through time, especially if a cycle of property devaluation and declining credit ratings begin at the municipal level (Shi and Moser, 2021; Treuer et al., 2018).

We acknowledge the limitations inherent within our approach. The response of forty individuals within the interviews are not reflective of climate mobility sentiments across the MDC public, but instead should be used to prompt discussion on the implications of varying levels of societal vulnerability and exposure to flood hazards on future climate mobility and adaptation. Our survey responses aimed to add robustness and more generalizability to the results. However, embedding flood hazard maps within an online survey does not allow respondents to fully engage with flood exposure information. Respondents may not have had enough time to internalize this information, did not understand the information, or may have disregarded the information. We recommend that experts and decision-makers engage with residents to convey flood-risk exposure information, as well as potential climate-driven transformations and futures. Future research should consider how in-depth and iterative engagement with flood risk information may influence household climate-mobility decision-making.

## 5. Conclusion

Sea-level rise and related flooding are currently shifting preferences for desirable residential locations, an emerging trend with the potential to reshape future housing markets. Participating residents across Miami-Dade County indicated that new normal conditions of flooding, primarily driven by precipitation-based events, have been occurring frequently across the county, prompting ad-hoc adaptation by current residents. These same events, including non-extreme compound flooding, are impacting residents, from damaged vehicles to missed work and school days, and reshaping mobility decisions in the process. Interviewees described considerations for climate mobility decision-making whereby financial and economic pressures heavily influenced decisions across the socio-economic spectrum, which could exacerbate existing societal inequities. Considerations of climate risks are slowly being integrated into mobility decisions, but in-situ adaptations are still preferred over moving away, even under scenarios of higher sea-level rise. However, without a society-wide commitment to long-term sea-level rise adaptation, the ability to adapt may exceed individual capacities and may prompt more residents to consider mobility while also exacerbating conditions of being trapped with diminishing options.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Nadia A. Seeteram reports financial support was provided by National Science Foundation. Nadia A. Seeteram reports financial support was provided by Florida International University College of Arts Sciences & Education.

## Data availability

The data that has been used is confidential.

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## Appendix A. Supplementary material

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