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Spatial heterogeneity of preferences for sea-level rise adaptation: Empirical evidence from yearlong and seasonal residents in Florida

Sisi Meng [a,*], Pallab Mozumder [b]

[a] Keough School of Global Affairs, University of Notre Dame, 4033 Jenkins and Nanovic Halls, Notre Dame, 46556, IN, United States
[b] Dept. of Earth & Environment, Dept. of Economics and Institute of Environment, Florida International University, United States

A R T I C L E I N F O

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A B S T R A C T

A growing body of evidence suggests that the global sea level has been increasing at an accelerating rate. This trend, which is linked to global warming, poses a significant threat to the communities living in low elevation coastal areas. This study aims to investigate public preferences and estimate the economic value of sea-level rise (SLR) adaptation projects in Florida. We compute the households' willingness to pay (WTP) for different attributes of SLR adaptation programs using a series of choice experiments embedded within a household survey of selected communities in Florida. We find strong spatially heterogeneous preferences in both the short-term and long-term adaptation plans. Moreover, Florida's seasonal residents are willing to pay more than yearlong residents due to their higher risk perceptions and higher income levels. There are few studies in the present literature that compare adaptation preferences across this demographic gradient. Thus, the empirical findings can contribute significantly to the design of optimal adaptation programs and policies to tackle the sea-level rise caused by climate change.

1. Introduction

Accumulating evidence indicates that global sea levels are rising at an accelerating rate, posing a serious threat to low-lying coastal communities. Florida's more than 1,200 miles of coastline is particularly vulnerable to sea-level rise (SLR) due to its low elevation, subtropical climate, and densely populated coastal communities. In the U.S., Florida is anticipated to account for 51% of the net increase in housing in exposed areas by 2030 (Maloney and Preston, 2014). Miami, which is home to over a quarter of the at-risk population, has been identified as the world's most economically vulnerable city to the SLR (Hauer et al., 2016). Even a small increase in sea level would inundate and flood thousands of acres of highly developed coastal communities. Significant environmental changes, severe property damages, and widespread disruptions in economic development (e.g., tourism, agriculture, and transportation) are expected (Wdowinski et al., 2016). Without comprehensive climate actions, the effects of climate change will only exacerbate, aggravating the threats of SLR.

Lausche and Maier (2013) proposed three stages to building resilience to SLR in coastal communities: (1) acknowledging SLR as a threat; (2) assessing risks and vulnerabilities; and (3) developing corresponding adaptation plans. To determine the optimal adaptation strategy, it is also necessary to differentiate between short-term and long-term adaptation measures. Molinaroli et al. (2019)

* Corresponding author.
E-mail addresses: smeng@nd.edu (S. Meng), mozumder@fiu.edu (P. Mozumder).

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emphasized the importance of long-term adaptation measures in creating a shared responsibility for the future. However, a significant knowledge gap remains regarding public preferences towards alternative adaptation plans and the underlying mechanisms driving these preferences. In this context, this study aims to understand public preferences and estimate the willingness to pay for short-term and long-term SLR adaptation projects in Florida.

Empirical studies that investigate public preferences for *climate change mitigation and adaptation* practices have primarily utilized stated preference methods, which are based on survey responses to elicit individuals' preferences for ecosystem services, public goods, and policies related to climate change, among other things. For a few examples, Berk and Fovell (1999) conducted an early investigation into the factors shaping respondents' preferences, including concerns for quality of life, wildlife habitats, the economy, and future inheritance. Viscusi and Zeckhauser (2006) assessed risk perceptions of more aggressive climate change and found that a slight majority (51%) of respondents were willing to pay more to reduce climate change risks. Lee and Cameron (2008) found that U.S. residents were generally more willing to pay for climate change mitigation if they perceived the impacts to be substantially harmful. Schaafsma et al. (2012) valued alternative flood risk mitigation and adaptation strategies, highlighting the impact of location, risk perceptions, and income levels on willingness to pay for flood insurance. Layton and Brown (2000) examined preferences for mitigating the effects of global climate change over two different time horizons. The results indicated that people were willing to pay more for more substantial losses, but preferences did not vary between the two widely different time frames.

Studies investigating public preferences for *SLR mitigation and adaptation* practices primarily rely on stated preference methods due to the hypothetical nature of sea level rise. Some studies have indirectly examined the risks associated with SLR by estimating the willingness to pay for reducing flood risks caused by storm surge and SLR (Birol et al., 2009; Botzen et al., 2009; de Koning et al., 2019; Withey et al., 2019). Studies that directly investigated public preferences for reducing SLR risks found that respondents were generally supportive of mitigation or adaptation measures and were willing to pay to avoid the risks (Kloos and Baumert, 2015; Remoundou et al., 2015; Jamero et al., 2017; Narayan et al., 2020). However, coastal communities have also expressed objections, citing concerns about the suitability of strategies created in non-local contexts (Crichton et al., 2020), corruption that appropriates adaptation funds (Vásquez et al., 2022), or other issues that are deemed more pressing than SLR risks (Thomas et al., 2015).

Within the U.S. context, Akerlof et al. (2016) illustrated that coastal residents in Maryland were aware of local SLR and increased coastal flooding risks but were uncertain about when impacts would become significant. Akerlof et al. (2019) found that SLR is a less salient concern to the public than climate change, even among high-risk coastal residents in the mid-Atlantic USA. Sikder and Mozumder (2020) showed that environmentally concerned Floridians, residents living closer to the coast, and frequent beachgoers were more likely to support aggressive adaptation measures, such as prohibiting the development of low-lying coastal areas. Treuer et al. (2018) studied homeowners' preferences on SLR adaption in South Florida and found that 75% of participants were willing to pay for adaptation. However, these homeowners also intended to move out over the three studied periods (2016, 2030, 2050). Although the aforementioned studies utilized survey data to understand local adaptation preferences, none used choice modeling to analyze public decisions regarding alternative SLR policy options. This study aims to fill the gap in the literature by using choice experiments to elicit the willingness to pay and provide economic values for SLR adaptation. Valuing the benefits of adaptation must be integrated into climate risk research to address the impacts of rising seas.

Moreover, we examine the spatially heterogeneous preferences in household choices by incorporating detailed spatial information generated by Geographical Information Systems (GIS) into the survey data. Spatial factors shape public preferences and willingness to pay for ecosystem service changes at study sites (Schaafsma et al., 2012). Brouwer et al. (2010) referred to spatial heterogeneity as the concept that respondents are expected to value environmental changes based on their place of residence. Johnston et al. (2002) observed that stated preference studies rarely incorporate spatial attributes in associated econometrics. Studies that ignore the spatial heterogeneity could also produce biased parameter estimates even with a representative sample (Concu, 2007). Some studies have considered spatial preference heterogeneity by estimating separate choice models for different locations or adding regional dummy variables in the choice models (Bergmann et al., 2008; Brouwer et al., 2010; Dachary-Bernard et al., 2019). Other studies have used distance as the primary indicator for preference heterogeneity (Tait et al., 2012; Jørgensen et al., 2013; Johnston et al., 2019). In this study, we investigate whether proximity to coastlines, elevation, and inundation risks influence the willingness to pay for SLR adaptation plans.

To effectively assess residents' perceptions and preferences, the influence of place attachment should be taken into consideration because it is an emotional bond that affects behavior (Burley, 2010; Snider et al., 2011). (Steimanis et al. (2021)) identified place attachment and risk aversion as the two primary reasons people remain in sea-level rise threatened coastal regions. Florida has some distinctive features regarding the socio-demographic composition of its residents. Warm weather throughout the winter season, coastal amenities, and the absence of state income tax all contribute significantly to attracting people to stay for a few months of the year. Many of these residents own properties in Florida though they avoid visiting during hurricane seasons. Regardless of the reasoning behind being a seasonal or yearlong resident, studies have shown significant differences in attitudes and perceptions between the two groups.

In a study comparing the attitudes towards land use controls and economic development activities, Green et al. (1996) found that, compared to seasonal residents, permanent residents are more supportive of local economic development activities but less likely to favor land use planning. Seasonal residents may not have strong place dependence on their surrounding environment because of the transient nature of their residency. However, the influence of place attachment on preferences may be outweighed by other socio-economic characteristics, such as income. For example, Green et al. (1996) found that seasonal residents are more willing to pay taxes. Landry et al. (2011) designed a choice experiment to examine how residents of the New Orleans metropolitan area as well as non-residents preferred options for rebuilding New Orleans' man-made storm defenses, restoring natural storm protection, and improving evacuation options. The results indicated that individuals were willing to pay for increased storm protection for New

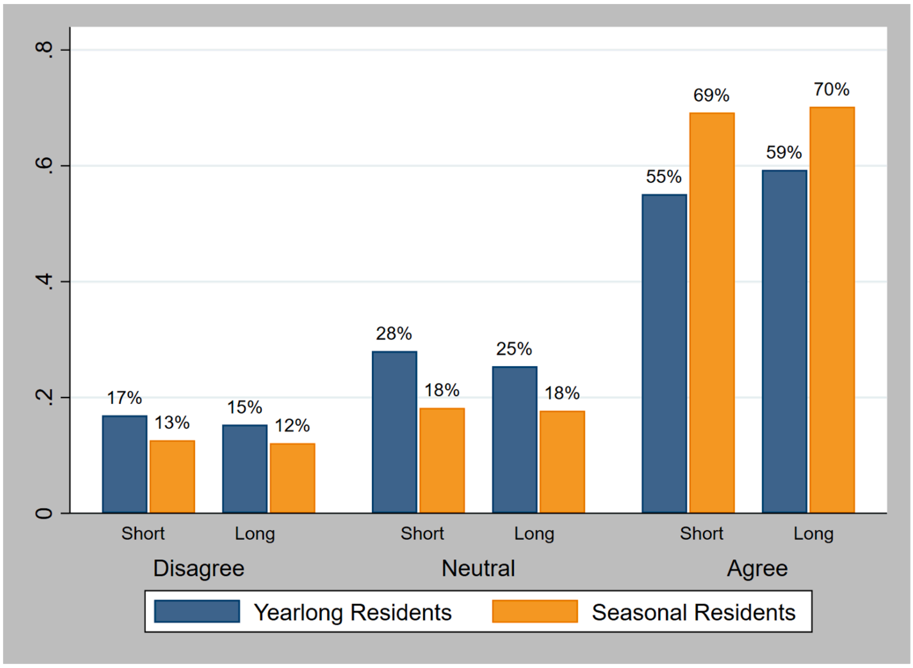

Fig. 1. Differences in risk perception among yearlong and seasonal residents.

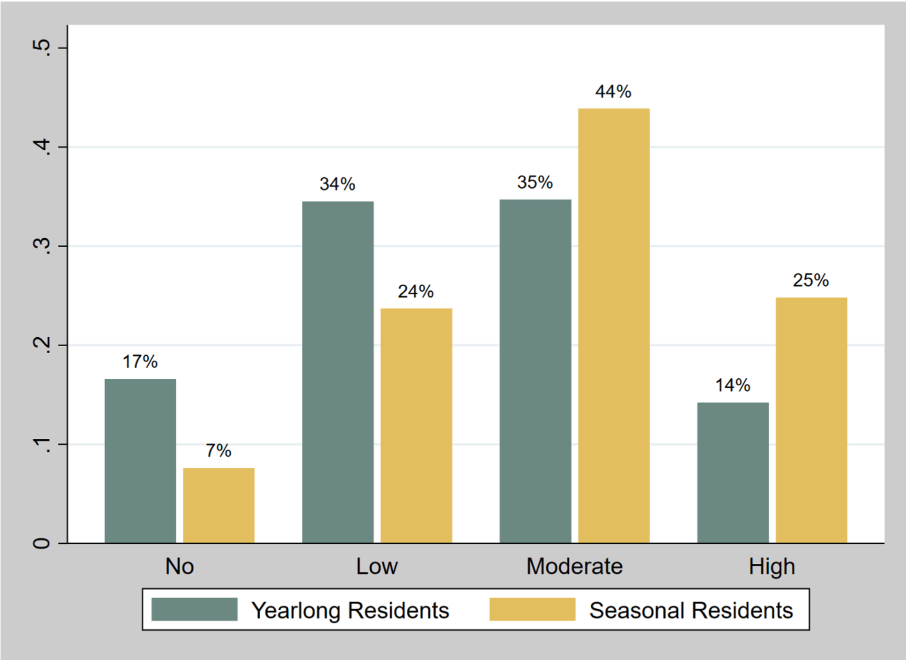

Fig. 2. Differences in SLR concern among yearlong and seasonal residents.

Orleans, but non-residents, who were believed to have no place attachment, were willing to pay more due to their higher income levels. Against this backdrop, this study pays special attention to the differences and similarities in perceptions and preferences among Florida's yearlong and seasonal residents.

Table 1
Descriptive statistics of respondent characteristics.

	Combined	Yearlong	Seasonal
Average age (years)	52.4	54.7	46.1
Gender (%)			
Male	47.7	50.7	39.4
Female	52.3	49.3	60.6
Education (%)			
Less than high school	6.1	7.5	2.5
High school	34.2	42.2	12.1
Some college	27.8	24.0	38.4
Bachelor's degree or higher	31.8	26.4	47.0
Income (%)			
Less than $19,999	12.7	14.7	7.1
$20,000 to $100,000	66.0	66.5	64.6
$100,000 or more	21.3	18.7	28.3
Employment status (%)			
Employed/Self employed	50.3	46.7	60.1
Unemployed	12.6	14.4	7.6
Retired	32.2	33.1	29.8
Other	4.9	5.8	2.5
Average household size	2.5	2.5	2.6
Households with children (%)	26.1	23.6	32.8
Obs	748	550	198

2. Data and choice experiment design

2.1. Survey and sample characteristics

We contracted a reputable survey company, GfK, to employ their KnowledgePanel methodology to ensure the sample was representative of the population. Specifically, we targeted households (18 and older) in selected coastal communities in Florida, including both yearlong and seasonal residents at risk of SLR. The survey was carried out online in July 2014 over four weeks, with a total of 814 respondents. The average completion time was about 23 min. Approximately 73% of the respondents identified themselves as yearlong residents and the remaining 27% as seasonal residents. About 96% of the yearlong residents remained in Florida for all 12 months of the year, while the majority of the seasonal residents stayed for 6 months or less. Due to incomplete information, 748 responses are used in this study, with 550 yearlong residents and 198 seasonal residents.

The first part of the survey focused on household risk perceptions and concerns regarding the impacts of SLR. Respondents were asked to indicate to what extent they agree or disagree with the following three statements: 1) increased sea-level rise is real and we will experience impacts in the short-term future (within 10–20 years); 2) increased sea-level rise is real and we will experience impacts in the long-term future (within 30–50 years); 3) increased sea-level rise is not real and there will be no impact.

Although previous literature has suggested that yearlong residents are more aware of their surroundings, our results show that seasonal residents have a relatively higher SLR risk perception. Approximately 69% of the seasonal respondents agreed (or slightly agreed) with the short-term impact of SLR compared to only 55% of yearlong respondents (as shown in Fig. 1). The risk perception for seasonal respondents was also consistent (from 69% to 70%) regarding the long-term impact. Although a slightly higher percentage of yearlong respondents acknowledged the SLR impacts in the long term (from 55% to 59%), their risk perception was still lower than that of seasonal respondents. In addition, disagreement and neutrality regarding the impact of SLR were more prevalent among yearlong respondents.

The respondents were also asked to indicate their level of concern about the projected impacts of SLR on their well-being, including health, finances, and property. The majority of the respondents expressed moderate concern about SLR impacts (see Fig. 2). Consistent with their higher risk perceptions, a greater proportion of seasonal respondents (25%) reported being highly concerned compared to yearlong respondents (14%). In contrast, a higher percentage of yearlong respondents reported being unconcerned or less concerned than seasonal respondents.

The average age of the respondents was 52 years old, and 48% were male. About 50% of the respondents were employed or self-employed, 13% were unemployed, and 32% were retired. The average family size was 2.5, which was comparable to the Florida average (2.48). About 26% of the respondents had children. Notably, seasonal respondents had higher levels of educational attainment and income compared to yearlong respondents. Among yearlong respondents, 50% had a less than high school diploma and 26% had a Bachelor's degree or higher. In the case of seasonal respondents, only 15% had a less than high school diploma, and 47% had a college degree or higher. The average annual income level was $40,000 to $49,000 for yearlong respondents and $60,000 to $75,000 for seasonal respondents. Detailed descriptive statistics of respondent characteristics are summarized in Table 1. Based on the socio-demographic composition of the respondents, the sample collected is representative of the Florida population.

Table 2
Attribute levels used in the choice experiment.

Time Horizon	Attribute	Description	Levels
Short Term (10 – 30 Years)	Land	Purchase of vulnerable lands and properties	0, 10%, 20%, 30%, 40%
	Drainage	Relocation of low-lying or underground drainage	0, 30%, 40%, 50%, 60%
	Pump	Installation of new pump stations	0, 10, 20, 40, 50
	Regulation	New regulation for raising elevation requirements	4 feet, 3 feet, 2 feet
	Payment	Payment (in annual local tax over the next 10 years)	$0, $30, $40, $60, $80
Long Term (30 – 50 Years)	Wetland	Coastal wetland restoration	0, 30%, 40%, 50%, 60%
	Flood	Urban flood reduction	0, 30%, 40%, 50%, 60%
	Regulation	New regulation for raising elevation requirements	4 feet, 3 feet, 2 feet
	Payment	Payment (in annual local tax over the next 20 years)	$0, $40, $50, $80, $100

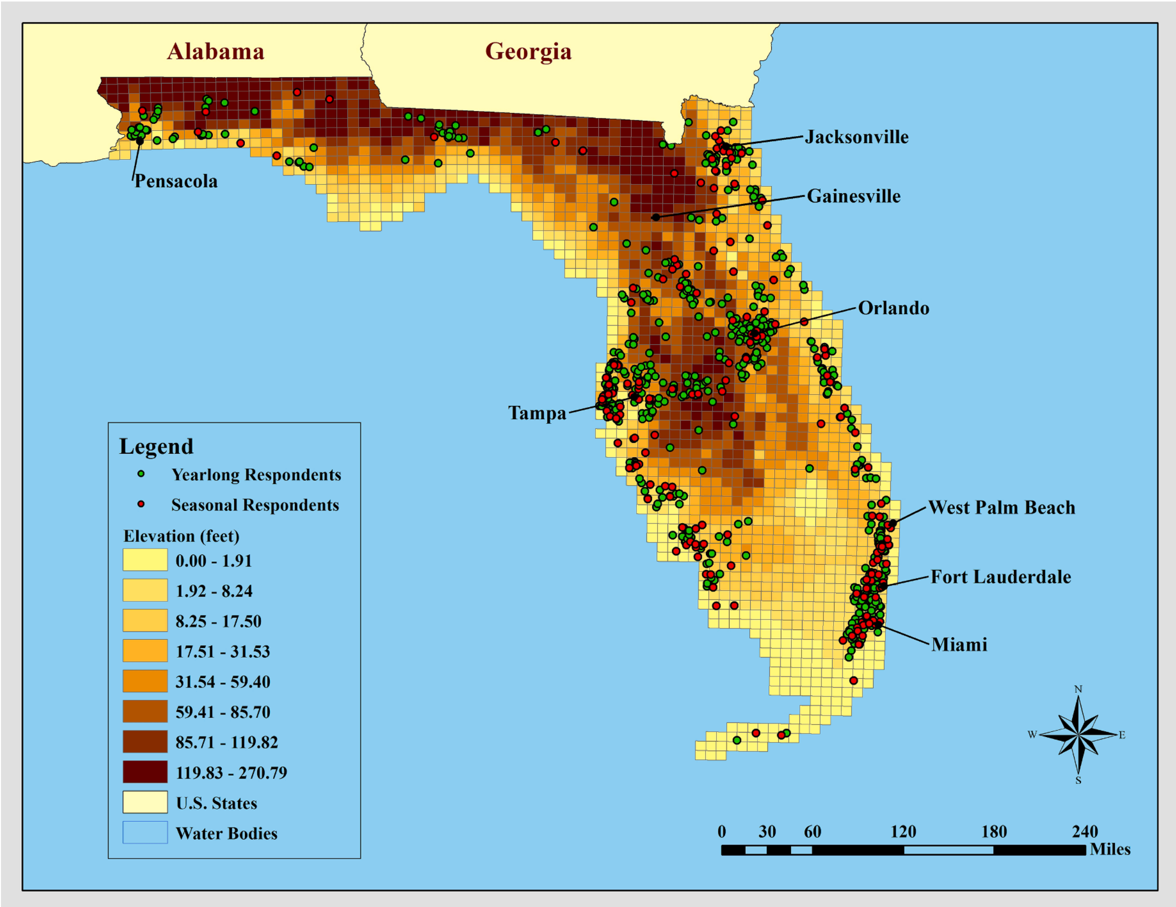

Fig. 3. Elevation Map of Florida and locations of surveyed respondents.

2.2. Choice experiment design

To follow the standard choice experiment approach, the surveyed respondents were given various options for adaptation plans with varying levels of adaptation strategies and were then asked to the one they would be most willing to pay for. To assess if and how preferences vary with time, we also compared the responses for short-term and long-term settings, given the increasing risk of SLR. According to the USACE (2009)) and SFRCC (2011), the sea level in South Florida is projected to rise from three to seven inches by 2030 and nine to twenty-four inches by 2060. Accordingly, we conducted two separate choice experiments to evaluate the impacts of climate change for two distinct timeframes: a short-term period of 10–20 years and a long-term period of 30–50 years.

The short-term choice experiment contained adaptation strategies that are expected to be effective within a timeframe of 10–20 years. These attributes included strategies such as purchasing coastally vulnerable land and properties, relocating low-lying or

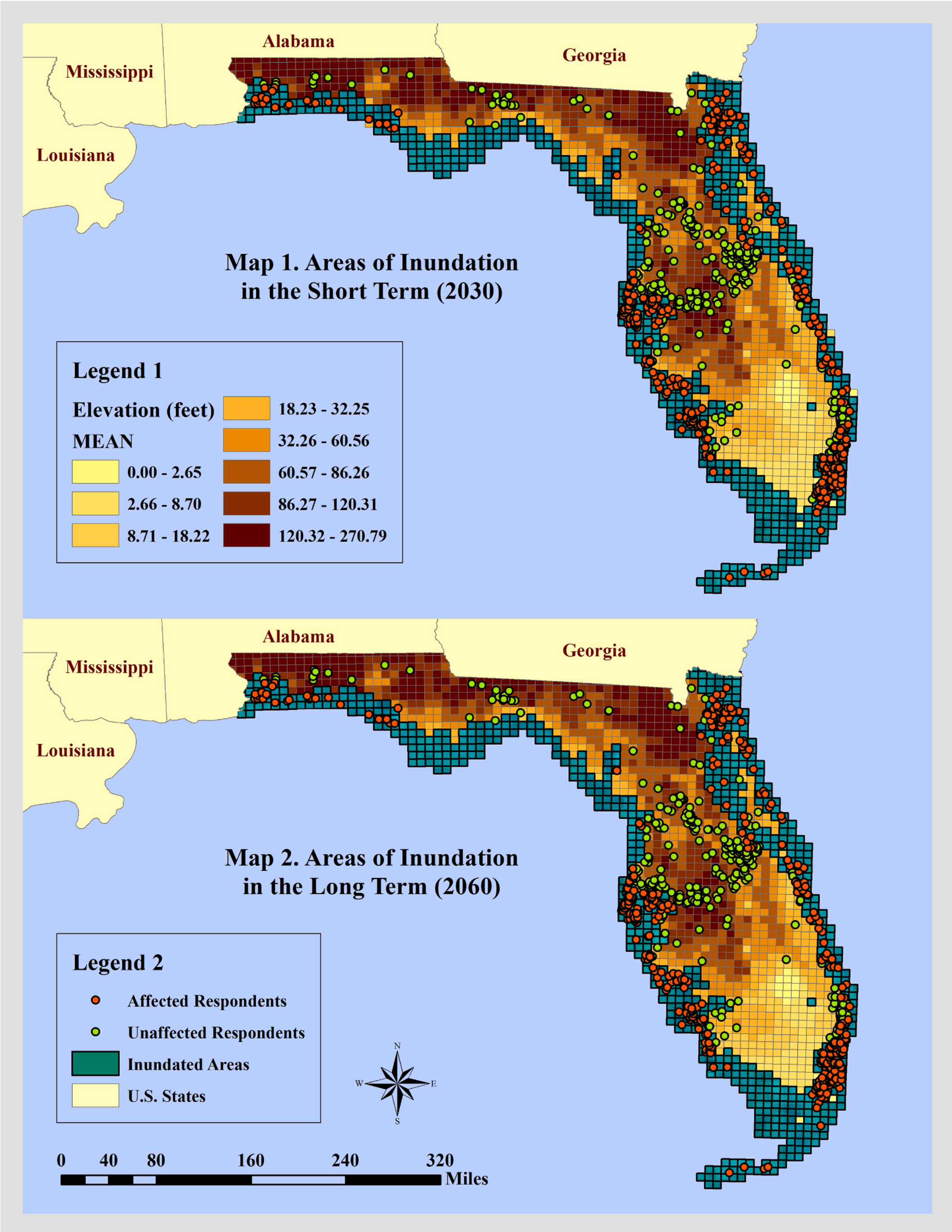

Fig. 4. Areas of inundation in Florida and the affected respondents.

underground drainage, and installing new pump stations. The proposed funding mechanism involved an annual local tax for the next 10 years. The experimental design consisted of 32 choice tasks, and each respondent was randomly assigned a choice card. We designed the long-term adaptation choice experiment to account for the escalating impacts of SLR in the next 30–50 years. The cards included more holistic approaches to adaptation (e.g., restructuring current infrastructure, coastal wetland restoration, and urban flood management) with an annual local tax for the next 20 years. The experimental design consisted of 16 choice tasks, and each respondent was randomly shown one choice card. The number of choice cards is lower compared to the short-term choice experiment due to the lower number of attributes. In addition to the attributes designed to accommodate both short-term and long-term effects of SLR, we imposed a ”new regulation for raising elevation requirements for coastal propertiesc” as a potential consequence of choosing

Table 3
Descriptive statistics of fund, risk perceptions, and spatial information of respondents.

Variable	Description	Mean (Standard Deviation)		
		Combined	Yearlong	Seasonal
Fund(SR)	The federal government will commit a matching fund for implementing the short term adaptation plans (=1 if yes, 0 if no)	0.484	0.475	0.510
		(0.50)	(0.50)	(0.50)
Fund(LR)	The federal government will commit a matching fund for implementing the long term adaptation plans (=1 if yes, 0 if no)	0.487	0.487	0.485
		(0.50)	(0.50)	(0.50)
Impact(SR)	Increased sea level rise is real and we will experience impact in the short-term future (=1 if strongly disagree, 5 if strongly agree)	3.626	3.545	3.848
		(1.23)	(1.23)	(1.20)
Impact(LR)	Increased sea level rise is real and we will experience impact in the long-term future (=1 if strongly disagree, 5 if strongly agree)	3.751	3.680	3.949
		(1.23)	(1.24)	(1.21)
Impact (No)	Increased sea level rise is not real and there will be no impact (=1 if strongly disagree, 5 if strongly agree)	2.171	2.142	2.253
		(1.26)	(1.20)	(1.41)
Concern	Concern about the projected impacts of sea level rise on your well-being (=1 if no concern, 4 if high concern)	2.570	2.465	2.859
		(0.93)	(0.93)	(0.88)
Distance	Log distance from respondents to the nearest coastline (unit: meter)	9.566	9.654	9.322
		(1.20)	(1.19)	(1.20)
Elevation	Average elevation in the 10*10 km square where respondents fall inside (unit: feet)	38.887	42.220	29.629
		(39.88)	(41.41)	(33.67)
Inund2030	The 10*10 km square is expected be inundated by the year of 2030 (=1 if yes, 0 if no)	0.557	0.522	0.657
		(0.50)	(0.50)	(0.48)
Inund2060	The 10*10 km square is expected be inundated by the year of 2060 (=1 if yes, 0 if no)	0.584	0.547	0.687
		(0.49)	(0.50)	(0.46)

not to pay for adaptation plans. In case of inaction, this regulation will be imposed to avoid high insurance premiums. This attribute is present in both choice scenarios as it represents a trade-off irrespective of the timeframe.

Furthermore, we evaluated financing preferences for the adaptation strategies by assessing whether the willingness to pay for short-term or long-term measures changed when the federal government matched individual contributions. In doing so, respondents were randomly assigned to have an adaptation plan with or without a matching fund from the federal government – for every $1 raised for adaptation plans locally, the government will commit $1 towards this fund for implementation. The summary of attributes and their corresponding levels are presented in Table 2. Appendix A provides an example of a short-term choice card, and Appendix B provides an example of a long-term choice card with the matching fund program shown to respondents.

2.3. GIS data

The spatial distribution of surveyed respondents produced using ArcGIS is shown in Fig. 3, with their locations geocoded based on latitude and longitude information obtained during the survey data collection. The majority of respondents resided along the coastline, which is the focus of our study, and several clusters were observed in major cities in Florida, labeled on the map. The figure also shows the locations of yearlong and seasonal respondents, indicated by green and red circles, respectively. Based on this spatial distribution, we believe that our sample and the subsamples are representative of the population affected by SLR risks in Florida.

Fig. 3 also provides an elevation map of Florida using data obtained from the Florida Geographic Data Library (FGDL). The original dataset contains a five-meter cell size Digital Elevation Model (DEM, 2013) covering the State of Florida, which we spatially joined into the generated 10*10 km grids. South Florida lies at a lower elevation than northern Florida, and much of the state is at or near sea level. Given the specific location of each surveyed respondent, the elevation information can be extracted consequently. Furthermore, the proximity to coastline can be calculated by measuring each respondent's location to its nearest coastline. Note that there is a positive correlation between elevation and distance to the coastline in Florida.

To examine the short-term and long-term impacts of SLR, we estimated potential inundation risks every ten years in Florida utilizing an SLR Inundation Surface Calculator embedded in GIS (see Appendix C). The calculator uses USACE sea-level change projection methodology with National Oceanic and Atmospheric Administration (NOAA) tide gauge data and sea-level trends. Fig. 4 presents the generated inundation areas and affected respondents in 2030 (representing the short term) and 2060 (representing the long term). We used the high projection curve with tidal datum values as Mean Higher High Water (MHHW) at the Key West tide gauge station. The generated inundation output was then spatially joined into the 10*10 km grids to obtain the inundation area at each grid. If the calculated inundation area had a positive value, the grid was considered as an inundation grid, and respondents who fell inside that grid were considered vulnerable to SLR inundation risks. Fig. 4 represents the vulnerable respondents in orange circles and unaffected respondents in light green circles. Notably, more inundated grids, particularly in South Florida, can be observed in the long term (Map 2) than in the short term (Map 1). As a result, we identified 55.7% as vulnerable respondents in 2030 and 58.4% in 2060 in our sample. Detailed descriptive statistics from both the survey data and GIS data are summarized in Table 3.

3. Model specification and hypotheses

The choice experiment method is based on the Random Utility Theory (RUT), in which individuals are assumed to select the alternative that yields the highest utility. Specifically, an individual, labeled as n, faces a choice among J alternatives. The utility the individual obtains from alternative j is then U_{nj}, where $j = 1,\ldots,J$. Because the individual chooses an alternative that provides the greatest utility, the probability that the individual n chooses alternative i depends on the fact that the utility provided by alternative i is the highest among any other options j, expressed as:

$$P_{ni} = Prob(U_{ni} > U_{nj}, \forall j \neq i) \tag{1}$$

As proposed by McFadden et al. (1973) and Train (2009), we cannot directly observe an individual's utility, but we can observe some attributes of the alternatives faced by the individual and some attributes of the individual. The observed component of utility is usually specified to be linear in parameters, such that:

$$U_{ni} = \sum \beta_{nik} X_{nik} + \epsilon_{ni} \tag{2}$$

where X_{nik} is a vector of k choice-related characteristics consisted of observed attributes and individual characteristics, β_{nik} is a vector of k parameters to be estimated, and ϵ_{ni} is the random component that captures factors that affect utility but are not included.

In this study, individuals make a choice between two alternative SLR adaptation plans (basic and extensive) compared to the status quo option. Adapting and preparing for SLR can be realized at certain costs as annual tax payment, and the monetary payment of not adapting to SLR is zero. Accordingly, Eq. (2) can be rewritten as:

$$U_{ni} = \alpha + \sum \beta_A A_{ni} + \beta_P P_{ni} + \sum \beta_H H_{ni} + \epsilon_{ni} \tag{3}$$

where α is the alternative specific constant (ASC), β_A is the vector of coefficients in choice attributes A, β_P is the coefficient of the payment attribute P, and β_H is the vector of coefficients related to the household characteristics H, including attitudinal factors and socio-economic factors.

We aim to test three specific hypotheses in this study. The first hypothesis focuses on spatially heterogeneous preferences by examining the distance-decay effect, elevation effect, and inundation effect. The distance-decay effect can be measured by the Euclidean distance from individual n to his or her nearest coast c, which can be tested using Eq. (4):

$$U_{ni} = \alpha + \sum \beta_A A_{ni} + \beta_P P_{ni} + \sum \beta_H H_{ni} + \beta_D Log(D_{nci}) + \epsilon_{ni} \tag{4}$$

where β_D is the coefficient of the distance variable in the log form. The first null hypothesis is that there is no distance-decay effect on preferences among respondents:

$$H_1^0 : \beta_D = 0 \tag{5}$$

The null hypothesis can be rejected if spatial heterogeneity exists, meaning that there is a significant effect of respondents' distance to the nearest coast on their choice outcome. Alternatively, we could test the elevation effect and the inundation effect in a similar way. The elevation effect is measured by the average elevation of the 10*10 km grid. The inundation effect uses a dummy variable, which takes the value 1 if the individual will be affected as a result of the projected SLR in the short term (*Inund2030*) or the long term (*Inund2060*).

The second hypothesis considers the differences in preferences between Florida's yearlong and seasonal residents. In doing so, an individual n is first identified as either a yearlong resident y or a seasonal resident s, and Eq. (4) can be further expanded to:

$$U_{yi} = \alpha_y + \sum \beta_A A_{yi} + \beta_P P_{yi} + \sum \beta_H H_{yi} + \beta_D Log(D_{yci}) + \epsilon_{yi} \tag{6}$$

$$U_{si} = \alpha_s + \sum \beta_A A_{si} + \beta_P P_{si} + \sum \beta_H H_{si} + \beta_D Log(D_{sci}) + \epsilon_{si} \tag{7}$$

The second null hypothesis is presented as:

$$H_2^0 : \alpha_y = \alpha_s \tag{8}$$

Although we can test the second hypothesis by comparing all the coefficients from Eq. (6) and (7), the ASC offers a general indication of respondents' preferences. Rejection of the null hypothesis will imply that yearlong residents and seasonal residents have

Table 4
Results of multinomial logit model (choice on short-term SLR adaptation plan).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7		Model 8		Model 9	
	Combined	Combined	Combined	Combined	Combined	Combined	Yearlong	Seasonal	Yearlong	Seasonal	Yearlong	Seasonal
ASC	1.296***	−1.213	1.037	−0.669	−1.481	−1.498	0.146	2.936***	−2.108**	−0.089	0.066	4.229
	(0.41)	(0.92)	(1.22)	(0.96)	(0.93)	(0.94)	(0.44)	(0.98)	(0.99)	(2.61)	(1.38)	(3.70)
Land	0.612**	0.667**	0.633**	0.646**	0.658**	0.655**	0.488*	1.319**	0.512*	1.409*	0.485	1.251
	(0.26)	(0.28)	(0.28)	(0.29)	(0.28)	(0.28)	(0.28)	(0.64)	(0.30)	(0.83)	(0.31)	(0.84)
Drainage	1.330***	1.347***	1.370***	1.193***	1.281***	1.287***	1.422***	1.159	1.347***	2.725**	1.382***	2.782**
	(0.41)	(0.44)	(0.45)	(0.46)	(0.45)	(0.45)	(0.45)	(0.95)	(0.49)	(1.17)	(0.49)	(1.21)
Pump	0.625*	0.826**	0.797**	0.651*	0.753**	0.740**	0.302	2.192***	0.412	2.896***	0.378	2.762***
	(0.33)	(0.36)	(0.36)	(0.38)	(0.36)	(0.37)	(0.36)	(0.82)	(0.39)	(0.98)	(0.39)	(0.97)
Regulation	1.003	1.136	1.123	0.917	1.072	1.053	0.629	3.292**	0.517	5.282**	0.519	5.007**
	(0.63)	(0.70)	(0.70)	(0.73)	(0.71)	(0.71)	(0.69)	(1.56)	(0.74)	(2.18)	(0.75)	(2.18)
Payment	−0.057***	−0.064***	−0.063***	−0.060***	−0.061***	−0.061***	−0.054***	−0.069***	−0.062***	−0.074***	−0.060***	−0.073***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
ASC*Fund(SR)		0.798***	0.860***	0.903***	0.875***	0.864***			0.777***	1.255**	0.832***	1.467***
		(0.19)	(0.19)	(0.20)	(0.19)	(0.19)			(0.21)	(0.52)	(0.21)	(0.53)
ASC*Impact(SR)		0.385***	0.371***	0.403***	0.368***	0.368***			0.353***	0.555*	0.340***	0.528*
		(0.10)	(0.10)	(0.10)	(0.10)	(0.10)			(0.11)	(0.29)	(0.11)	(0.30)
ASC*Impact(No)		−0.208**	−0.202**	−0.184**	−0.216**	−0.220**			−0.243**	−0.186	−0.243**	−0.138
		(0.09)	(0.09)	(0.09)	(0.09)	(0.09)			(0.10)	(0.20)	(0.10)	(0.19)
ASC*Concern		0.272**	0.249**	0.203*	0.241**	0.245**			0.210	0.491	0.174	0.509
		(0.12)	(0.12)	(0.12)	(0.12)	(0.12)			(0.13)	(0.40)	(0.13)	(0.43)
ASC*Age		−0.003	−0.004	−0.003	−0.004	−0.004			0.006	−0.047**	0.005	−0.052**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)			(0.01)	(0.02)	(0.01)	(0.02)
ASC*Education		0.031	0.018	0.032	0.035	0.039			−0.004	0.272	−0.026	0.378
		(0.11)	(0.11)	(0.11)	(0.11)	(0.11)			(0.12)	(0.25)	(0.12)	(0.28)
ASC*Income		0.051**	0.050**	0.051**	0.051**	0.051**			0.036	0.107*	0.036	0.109*
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)			(0.03)	(0.06)	(0.03)	(0.06)
ASC*Employed		0.345	0.320	0.227	0.290	0.285			0.517**	−0.767	0.482**	−0.852
		(0.23)	(0.23)	(0.23)	(0.23)	(0.23)			(0.24)	(0.68)	(0.24)	(0.72)
ASC*Children		−0.088	−0.076	−0.036	−0.071	−0.078			−0.107	−0.108	−0.104	−0.060
		(0.12)	(0.11)	(0.12)	(0.11)	(0.11)			(0.13)	(0.38)	(0.13)	(0.36)
ASC*Distance			−0.227***								−0.208**	−0.505**
			(0.08)								(0.09)	(0.25)
ASC*Elevation				−0.015***								
				(0.00)								
ASC*Inund2030					0.681***							
					(0.19)							
ASC*Inund2060						0.676***						
						(0.19)						
ASC*Yearlong	−0.820***	−0.584**	−0.521**	−0.431	−0.503*	−0.499*						
	(0.22)	(0.26)	(0.26)	(0.26)	(0.26)	(0.26)						
N	2244	2244	2244	2244	2244	2244	1650	594	1650	594	1650	594
Pseudo-R2	0.055	0.123	0.127	0.149	0.131	0.131	0.035	0.124	0.102	0.229	0.106	0.239
Log-likelihood	−776.663	−720.504	−717.143	−699.663	−714.352	−714.424	−582.957	−190.483	−542.708	−167.713	−540.364	−165.508

Robust Standard errors in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$ significance level.

heterogeneous preferences towards SLR adaptation plans in Florida.

The third hypothesis relates to respondents' sensitivity to time horizons displayed in the choice experiment. Utilizing the two timeframes (i.e., a short-term impact, ST, and a long-term impact, LT), the Eq. (4) can be rewritten as:

$$U_{ni}^{ST} = \alpha^{ST} + \sum \beta_A^{ST} A_{ni}^{ST} + \beta_P^{ST} P_{ni}^{ST} + \sum \beta_H H_{ni} + \beta_D Log(D_{nci}) + \epsilon_{ni}^{ST} \tag{9}$$

$$U_{ni}^{LT} = \alpha^{LT} + \sum \beta_A^{LT} A_{ni}^{LT} + \beta_P^{LT} P_{ni}^{LT} + \sum \beta_H H_{ni} + \beta_D Log(D_{nci}) + \epsilon_{ni}^{LT} \tag{10}$$

where U_{ni}^{ST} is the utility obtained from choosing a short-term adaptation plan and U_{ni}^{LT} from choosing a long-term adaptation plan. Accordingly, the third null hypothesis is that respondents are not sensitive to time horizons.

$$H_3^0 : \alpha^{ST} = \alpha^{LT} \tag{11}$$

If we find that the short-term ASC and long-term ASC are different, we can reject the null hypothesis and conclude that respondents have different time preferences regarding SLR adaptation plans in Florida.

4. Choice experiment results and the willingness to pay

4.1. Estimation Results for the Short-term Adaptation Plan

We estimated nine random utility models to analyze the short-term choice. Table 4 presents the results for all respondents (Models 1–6) as well as for yearlong and seasonal residents (Models 7–9). In the basic "attribute only" model (Model 1), the *ASC* is positive and significant at the 1% level, indicating that respondents preferred the short-term SLR adaptation plan to the status quo. The coefficients of four choice attributes are also significant with expected signs. Improvements in coastal vulnerable lands, low-lying and underground drainages, and pump stations all positively affect the adaptation choice. *Payment* has a negative sign, implying that the option is less likely to be chosen if the cost is higher. The regulation attribute is insignificant.

Models 2–6 are the extended models estimated by interacting respondents' perceptions, socio-economic, and spatial variables with the *ASC*, aiming to evaluate the influence of respondent characteristics on their preferences. The coefficients of the interaction terms between *ASC* and matching fund, risk perception, concern, and household income are statistically significant with the expected signs. A matching fund by the federal government increases respondents' willingness to opt-in for the adaptation plan. Implementing a matching fund program can incentivize people to participate in the adaptation program. The positive signs of *ASC*Impact(SR)* and *ASC*Concern* indicate that respondents who were more aware of and more concerned about the short-term impacts of SLR are more willing to accept the adaptation plan. Conversely, respondents who did not believe in the SLR impacts were less likely to agree with the adaptation measures, as indicated by the negative sign of *ASC*Impact(No)*. Finally, higher income increases the probability of choosing the SLR adaptation plan. Wealthier households are generally willing to invest more to adapt to adverse environmental impacts.

Regarding spatial heterogeneity, Model 3 includes the distance variable, the coefficient of which has a significantly negative sign. Respondents who live closer to the coast have a higher probability of choosing the adaptation plan. Model 4 shows the elevation effect on the choice outcome as an alternative spatial factor to distance. The significant and negative sign indicates that respondents who live at relatively lower elevations value adaptation programs more. Models 5 and 6 investigate the differences in preferences between affected and unaffected respondents due to SLR inundation. The positive sign of *ASC*Inund2030* implies that respondents who fall into inundation areas in 2030 (short term) have a higher probability of choosing the short-term adaptation plan than unaffected respondents. The coefficient of *ASC*Inund2060* is also significantly positive, indicating that respondents expecting to be affected in the year 2060 (long term) also have a higher probability of choosing the short-term adaptation plan. The significant distance-decay effects, elevation effects, and inundation effects in the estimation results demonstrate a strong spatial heterogeneity, hence rejecting the first null hypothesis.

To determine whether seasonal residents have different preferences from yearlong residents, a dummy variable *Yearlong*, which takes the value 1 for yearlong respondents, was added to all the models in Table 4. The significantly negative sign of *ASC*Yearlong* (except for Model 4) indicates that, compared to seasonal residents, yearlong residents are less likely to support the adaptation plan. This implies that the influence of place attachment did not play a key role in yearlong residents' decisions to select an adaptation plan. Higher risk perceptions and higher income levels may be more dominant factors in climate change adaptation. Hence, we reject the second null hypothesis that yearlong and seasonal residents have the same short-term preference.

Models 7–9 examine the choice experiment results between yearlong and seasonal residents separately. According to the basic "attribute only" model (Model 7), the *ASC* remains positively significant for seasonal respondents but insignificant for yearlong respondents, consistent with the results when using the dummy variable *Yearlong*. The extended models also shed light on respondent characteristics in determining preferences between the two. Having a matching fund and a higher risk perception can positively influence the adaptation choice across both groups. Household income appears to be a significant determinant among only seasonal residents, and household concern is insignificant for both groups. In addition, *Age* is a significant determinant for seasonal respondents when choosing an adaptation plan. The negative sign implies that younger people among seasonal residents are more willing to adapt to SLR. Lastly, *Employed* is significant for yearlong respondents, indicating that employed yearlong residents are more likely to support adaptation compared to unemployed or retired yearlong residents. Lastly, significant interaction terms between *ASC* and the distance variable in Model 9 indicate strong distance-decay effects for both groups. It is worth noting that the ASC is significantly negative for

Table 5
Results of multinomial logit model (choice on long-term SLR adaptation plan).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7		Model 8		Model 9	
	Combined	Combined	Combined	Combined	Combined	Combined	Yearlong	Seasonal	Yearlong	Seasonal	Yearlong	Seasonal
ASC	−0.546	−2.105**	0.681	−1.756*	−2.178**	−2.210**	−1.081**	−1.667*	−2.350**	−3.942*	0.780	−1.815
	(0.43)	(0.99)	(1.36)	(1.00)	(0.99)	(0.99)	(0.45)	(0.89)	(1.05)	(2.25)	(1.56)	(2.83)
Wetland	1.953***	2.009***	2.099***	1.929***	1.979***	1.983***	1.906***	2.090**	1.920***	2.921***	2.062***	2.869***
	(0.41)	(0.44)	(0.45)	(0.45)	(0.44)	(0.44)	(0.45)	(0.97)	(0.49)	(1.00)	(0.50)	(1.00)
Flood	1.661***	1.974***	2.003***	2.049***	1.945***	1.956***	1.340***	2.989***	1.648***	3.532***	1.657***	3.542***
	(0.40)	(0.44)	(0.44)	(0.45)	(0.44)	(0.44)	(0.45)	(0.97)	(0.49)	(1.03)	(0.50)	(1.03)
Regulation	0.917	1.140*	1.234*	1.133*	1.094*	1.114*	0.492	2.373*	0.537	3.439***	0.651	3.417***
	(0.59)	(0.63)	(0.64)	(0.64)	(0.63)	(0.63)	(0.67)	(1.31)	(0.71)	(1.32)	(0.73)	(1.30)
Payment	−0.056***	−0.057***	−0.057***	−0.057***	−0.057***	−0.057***	−0.062***	−0.041*	−0.067***	−0.039*	−0.067***	−0.038*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
ASC*Fund(LR)		−0.041	−0.033	−0.061	−0.041	−0.037			0.099	−0.779	0.087	−0.726
		(0.19)	(0.19)	(0.19)	(0.19)	(0.19)			(0.21)	(0.51)	(0.22)	(0.50)
ASC*Impact(LR)		0.178*	0.183**	0.189**	0.179**	0.179**			0.125	0.350*	0.126	0.346*
		(0.09)	(0.09)	(0.09)	(0.09)	(0.09)			(0.10)	(0.21)	(0.10)	(0.20)
ASC*Impact(No)		−0.337***	−0.317***	−0.320***	−0.334***	−0.336***			−0.417***	−0.187	−0.405***	−0.166
		(0.08)	(0.08)	(0.08)	(0.08)	(0.08)			(0.10)	(0.20)	(0.10)	(0.20)
ASC*Concern		0.448***	0.421***	0.404***	0.429***	0.427***			0.376***	0.785***	0.327***	0.782***
		(0.11)	(0.12)	(0.12)	(0.12)	(0.12)			(0.13)	(0.29)	(0.13)	(0.29)
ASC*Age		0.001	0.001	0.002	0.001	0.001			0.006	−0.013	0.006	−0.015
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)			(0.01)	(0.02)	(0.01)	(0.02)
ASC*Education		−0.151	−0.181	−0.158	−0.155	−0.154			−0.140	−0.108	−0.180	−0.078
		(0.11)	(0.12)	(0.11)	(0.11)	(0.11)			(0.12)	(0.26)	(0.13)	(0.27)
ASC*Income		0.050**	0.050**	0.050**	0.049**	0.049**			0.047*	0.025	0.048*	0.019
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)			(0.03)	(0.05)	(0.03)	(0.05)
ASC*Employed		0.198	0.192	0.144	0.186	0.180			0.323	−0.596	0.288	−0.563
		(0.22)	(0.23)	(0.23)	(0.23)	(0.23)			(0.25)	(0.54)	(0.26)	(0.57)
ASC*Children		0.002	0.014	0.021	0.011	0.008			−0.002	−0.004	−0.001	0.001
		(0.12)	(0.12)	(0.12)	(0.12)	(0.12)			(0.14)	(0.23)	(0.14)	(0.23)
ASC*Distance			−0.288***								−0.308***	−0.224
			(0.09)								(0.10)	(0.18)
ASC*Elevation				−0.008***								
				(0.00)								
ASC*Inund2030					0.290							
					(0.19)							
ASC*Inund2060						0.339*						
						(0.19)						
ASC*Yearlong	−0.868***	−0.780***	−0.723***	−0.686***	−0.758***	−0.748***						
	(0.22)	(0.26)	(0.26)	(0.26)	(0.26)	(0.26)						
N	2244	2244	2244	2244	2244	2244	1650	594	1650	594	1650	594
Pseudo-R2	0.080	0.133	0.140	0.140	0.134	0.135	0.069	0.120	0.126	0.182	0.135	0.185
Log-likelihood	−755.822	−712.682	−707.025	−706.421	−711.508	−711.074	−562.261	−191.366	−528.024	−177.867	−522.863	−177.241

Robust Standard errors in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$ significance level.

Table 6
MWTP for each attribute in the short- and long-term.

Attribute		Combined		Yearlong		Seasonal	
		Basic	Extended	Basic	Extended	Basic	Extended
Short Term	Land	10.66	10.08	8.99	8.02	19.08	17.24
		(1.3, 20.0)	(0.8, 19.3)	(-1.9, 19.9)	(-2.3, 18.4)	(0.2, 37.9)	(-6.8, 41.3)
	Drainage	23.19	21.82	26.22	22.85	16.76	38.33
		(8.3, 38.0)	(7.3, 36.4)	(8.2, 44.2)	(6.0, 39.7)	(-10.3, 43.8)	(1.3, 75.3)
	Pump	10.90	12.70	5.56	6.25	31.71	38.06
		(-1.1, 22.9)	(0.5, 24.9)	(-7.7, 18.9)	(-6.8, 19.3)	(0.1, 63.4)	(0.8, 75.3)
Long Term	Wetland	34.82	36.93	30.61	30.69	50.81	74.79
		(14.5, 55.1)	(15.1, 58.7)	(11.2, 50.0)	(11.3, 50.0)	(-25.1, 126.8)	(-31.2, 180.8)
	Flood	29.62	35.23	21.52	24.67	72.65	92.35
		(11.1, 48.2)	(14.3, 56.1)	(4.1, 38.9)	(6.6, 42.7)	(-10.2, 155.5)	(-16.3, 201.0)

MWTP estimates with 95% confidence interval in parentheses. The extended models are calculated based on the distance model (Model 3 and Model 8 in Table 4 for the short term, Model 3 and Model 8 in Table 5 for the long term)

yearlong respondents in Model 8 but becomes insignificant in Model 9. The omission of spatial preference heterogeneity may produce biased and inconsistent parameters in the estimation result.

4.2. Estimation results for the long-term adaptation plan

Utilizing the same setting as the short-term case, nine different random utility models were estimated for the long-term choice, and the results are presented in Table 5. Overall, the coefficients of all choice attributes are significant. Improvements in a coastal wetland, reductions in flood risks, and more strict property regulations all positively affect the choice outcome. *Payment* has a negative sign as expected, implying a negative effect on respondents' utility. Also, the *ASC* has shown a significant negative sign, indicating that respondents did not prefer the long-term SLR adaptation plan to the status quo. Our third null hypothesis is rejected because of the difference in preference outcomes between short-term and long-term adaptation plans.

Models 2–6 are the extended models with the inclusion of the matching fund program, risk perception, and spatial heterogeneity. Similar to the results in the short-term choice models, the negative signs of the interaction terms *ASC*Yearlong* suggest that yearlong residents are more likely to vote against the long-term adaptation plan. Regarding household-level characteristics, the coefficients of the interaction terms *ASC*Impact(LR)*, *ASC*Impact(NO)*, *ASC*Concern*, and *ASC*Income* remain statistically significant with the expected signs. *ASC*Fund(LR)* becomes an insignificant variable in the long-term choice outcome. The distance and elevation variables are significant and negative, as presented in Models 3 and 4. Respondents who live closer to the coast or at relatively lower elevations have a higher probability of choosing the long-term adaptation plan. There are no significant differences in preferences between unaffected and affected respondents due to SLR inundation risks in 2030 (see Model 5). However, the affected respondents are more willing to select the long-term adaptation plan due to SLR inundation risks in 2060 (see Model 6). Accordingly, we can reject the first null hypothesis regarding spatial heterogeneity again in the case of long-term choice.

Table 5 also presents the estimation results examining seasonal and yearlong residents. According to the "attribute only" model (Model 7), the *ASC* coefficients are negative for both groups. This suggests that yearlong and seasonal residents make the same choice in voting against the long-term SLR adaptation plan. Hence, we fail to reject the second null hypothesis for the two groups in the long term. Risk perceptions and concerns remain important variables for both groups of respondents when deciding on an adaptation plan. However, unlike the short-term adaptation preference, when income was insignificant for yearlong residents, income is now significant for yearlong residents but not for seasonal residents. No spatial heterogeneity can be observed for seasonal respondents, while there is still a strong distance-decay effect for yearlong respondents. This finding could be explained by the fact that seasonal residents are relatively more likely to relocate in the future than yearlong residents. If so, spatial factors may not be important for seasonal residents making a long-term choice.

4.3. WTP and economic values for SLR adaptation plan

The marginal willingness to pay (MWTP) estimates for each choice attribute are presented in Table 6. The calculations are based on the basic "attribute only" model and the extended model with the distance variable. The results show that the average household in the combined sample is willing to pay $10–11 for vulnerable land purchases, $22–23 for drainage relocation, and $11–13 for new pump stations per year as proposed in the short-term adaptation plan. As to the long-term adaptation plan, an average household in the combined sample is willing to pay $35–37 for wetland restoration and $30–35 for flood risk reduction per year. In general, respondents find relocation of low-lying and underground drainages to be the most valued line of adaptation in the short term, and wetland restoration is the most valued adaptation strategy in the long term.

Results indicate that yearlong residents in Florida are willing to pay $8–9 per household for vulnerable land purchase, $23–26 for underground drainage relocation, and $6 for new pump stations in the short term each year. Yearlong residents are willing to pay about $31 per household for wetland restoration and $22–25 for flood risk reduction in the long term. Seasonal residents are willing to pay more than yearlong residents per year on the adaptation plans ($17–19 for vulnerable land purchases, $17–38 for underground

Table 7
Economic values for each attribute in the short- and long-term.

Discount Rate	Land	Drainage	Pump	Wetland	Flood
2%	$1,399,618,248	$3,029,729,184	$1,763,407,912	$22,145,632,395	$21,126,201,713
3%	$1,314,528,936	$2,845,537,836	$1,656,202,132	$19,313,592,743	$18,424,529,444
4%	$1,236,261,396	$2,676,113,458	$1,557,591,243	$16,907,952,201	$16,129,627,838
5%	$1,164,177,147	$2,520,073,942	$1,466,770,810	$14,858,289,259	$14,174,317,102
6%	$1,097,704,600	$2,376,181,982	$1,383,020,677	$13,106,630,625	$12,503,292,632
7%	$1,036,331,384	$2,243,328,453	$1,305,695,296	$11,605,125,504	$11,070,906,350
8%	$979,597,616	$2,120,517,854	$1,234,215,250	$10,314,175,582	$9,839,382,771
9%	$927,090,003	$2,006,855,542	$1,168,059,825	$9,200,927,565	$8,777,380,940
10%	$878,436,663	$1,901,536,507	$1,106,760,478	$8,238,054,925	$7,858,832,250

drainage relocation, $32–38 for new pump stations, $51–75 per household for wetland restoration, and $73–92 for flood risk reduction). The differences are most pronounced in the short-term installation of new pump stations and long-term flood reduction.

Assuming that our sample is representative of Florida's population, we can estimate a tentative economic value for SLR adaptation projects in Florida. We use the MWTP estimates from the extended model from the combined sample in Table 6. Aggregating all Florida's taxpaying households over the next 10 years at a discount rate of 5%, the economic values for a short-term SLR adaptation plan are approximately $1.2 billion for coastal vulnerable land purchase, $2.5 billion for underground drainage relocation, and $1.5 billion for installation of new pump stations. With Florida's taxpaying households aggregated over the next 20 years at a discount rate of 5%, the economic values for a long-term SLR adaptation plan are approximately $14.9 billion for wetland restoration and $14.2 billion for flood risk reduction. We performed a sensitivity analysis using discount rates ranging from 2% to 10%, with the calculated economic values presented in Table 7. These estimates provide valuable information for decision-makers to analyze sea-level rise adaptation and mitigation projects in Florida. Future research can also conduct a comprehensive cost-benefit analysis based on these values.

5. Conclusion

Sea-level rise has become a pressing issue for coastal residents, who are faced with the daunting task of weighing the potential impact of rising sea levels on low-lying areas, predicting its likely trajectory, and making tough choices about how to adapt to it while considering competing spending priorities (Ince, 2013). To address this challenge, this study aimed to investigate public preferences and estimate the economic value of SLR adaptation projects, both in the short term and in the long term. We utilized choice experiments to gain insights into households' perceptions and preferences regarding SLR, and estimated their willingness to pay for different attributes of SLR adaptation programs based on a representative sample from selected coastal communities across Florida. We also examined the differences and similarities in perceptions and preferences between Florida's yearlong and seasonal residents. By doing so, we hoped to gain a comprehensive understanding of the attitudes of coastal residents towards SLR and climate change adaptation and to inform the development of effective adaptation policies and strategies.

Our empirical findings highlighted the importance of accounting for spatial heterogeneity in environmental valuation by integrating various spatial and location variables generated by GIS into the survey responses. Specifically, respondents residing in areas closer to the coastline and at relatively lower elevations, including expected inundation zones, were more likely to opt for SLR adaptation plans. The results also found evidence to support attitudinal and demographic differences in respondents' preferences for environmental improvements. Those with higher risk perceptions, greater concerns, and higher income levels were more willing to choose adaptation plans. Seasonal residents were willing to pay more for adaptation plans than yearlong residents, likely due to their higher risk perceptions and higher income. Lastly, our results indicated that respondents are sensitive to the timeframe of adaptation plans. While coastal residents in Florida supported short-term SLR adaptation strategies within the next 10–20 years, they were less supportive of long-term adaptation plans within the next 30–50 years.

We acknowledge two notable limitations of this study. First, the survey design was based on the first regionally unified Sea Level Rise Projection for Southeast Florida in 2011 (SFRCC, 2011), while the most recent 2019 projection updated the anticipated sea-level rise, which is projected to be 10 to 17 inches by 2040 and 21 to 54 inches by 2070 (SFRCC, 2019). In this context, future studies are required to examine public preferences given the new projection. Second, in addition to seasonal residency, other socio-demographic factors, such as gender, housing ownership, and political preferences, may also play an important role in shaping public preferences but are not examined in this study. Respondent preferences for adaptation strategies may be influenced by the timing of the survey administration. For example, if the survey was conducted during a recent extreme weather event, such as a hurricane, respondents may be more likely to express support for SLR adaptation plans. Similarly, if the survey was conducted during an economic downturn, respondents may be less willing to pay for adaptation plans. Florida had not experienced any major hurricanes since Hurricane Wilma in 2005 until Hurricane Irma struck the state in 2017. Thus, future research could devote more efforts to exploring these factors and providing new evidence to help develop tailored strategies that consider the unique preferences and circumstances of different communities and demographic groups.

Despite the limitations, our results have significant implications for SLR adaptation policy development and implementation. Firstly, given that coastal residents were more supportive of short-term adaptation plans, there is a need to raise awareness about the long-term impacts of climate change and the significance of effective adaptation strategies to mitigate these impacts. Collaboration

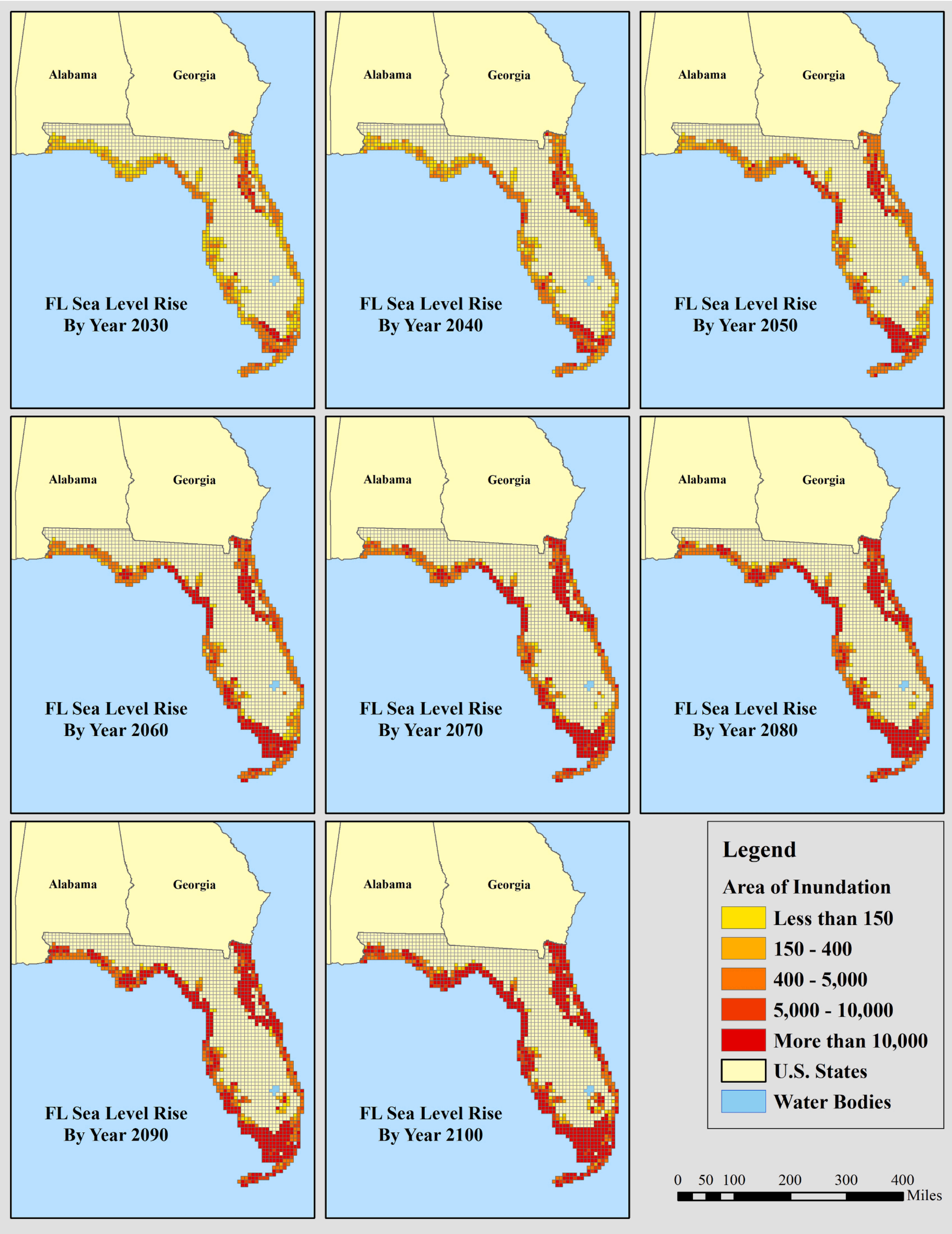

Fig. 5. Inundation Risk Map in Florida (2030–2100). Note: The inundation map is produced for Florida using an SLR Inundation Surface Calculator embedded in GIS from year 2030 to 2100. The tool is developed by University of Florida GeoPlan Center with funding from the Florida Department of Transportation Office of Policy Planning. Details can be found at http://sls.geoplan.ufl.edu/#intro. For the empirical analysis in this study, only the area of inundation for year 2030 and 2060 were used..

among local governments, institutions, and social media can help address the adverse effects of climate change on future generations, and developing more incentivized programs for long-term adaptation projects may be useful. Secondly, it is crucial to consider the place of residence or residency status when designing adaptation policies. Policies should also account for spatial preference heterogeneity. For example, different payment strategies could be employed for coastal residents and inland residents. Lastly, the study found that lower-income residents were less likely to pay for the adaptation plan, indicating that income inequality is a major impediment to program implementation. Therefore, socially vulnerable groups within communities ought to be given priority and provided with necessary aid or subsidies. Alternative financing mechanisms, such as grants or low-interest loans for low-income households, can be developed to ensure equitable access to adaptation strategies.

One major contribution of our study is that we explored the attitudes and preferences towards SLR adaptation options among seasonal and yearlong residents in Florida, providing valuable insights into their perspectives. Although there are no official statistics on seasonal residents in Florida due to the U.S. Census not accounting for seasonal residency, it is estimated that approximately one million "snowbirds" stay in Florida for a month or more during the winter, which increases the state's population by approximately 5% (Real Estate News, 2023). However, the proportion of seasonal residents would be higher than estimated if we considered two additional factors: first, seasonal residents may visit Florida during months other than winter, and second, since many of them own homes and are part-time residents of the state, they might not be classified as "snowbirds" but as part of the general population. To ensure adequate representation of seasonal residents, we intentionally designed the data collection process, resulting in 25% of the sample consisting of seasonal residents. Consequently, our study contributes to the limited research that compares adaptation preferences across this unique demographic gradient.

Furthermore, this study contributes to the growing body of literature on choice experiment studies in climate change adaptation. To our knowledge, this study is among the very few that uses the stated preference method with both spatial and temporal implications. In addition, our empirical findings have implications for multiple Sustainable Development Goals (SDGs), including SDG 13: Climate Action, which focuses on combating climate change and its effects through mitigation and adaptation strategies; SDG 14: Life Below Water, which emphasizes the need for the conservation and sustainable use of the ocean, seas, and marine resources that are particularly vulnerable to sea-level rise; and SDG 11: Sustainable Cities and Communities, which aims to create inclusive, safe, resilient, and sustainable cities and human settlements in the face of climate change and sea-level rise (UN, 2015). To address these global challenges, our estimates of the willingness to pay and the economic values of improved infrastructure and enhanced climate stability can provide important inputs for designing optimal adaptation plans and mitigation policies.

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Availability of data and material: Data will be made available upon reasonable request subject to compliance with IRB guidelines.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Example of a short-term choice card

The issue of sea-level rise is beyond the control of local communities but they can prepare for the impacts through implementing various adaptation strategies. The following question presents several adaptation plans, with various strategies aimed at adapting to increased sea-level rise, in the short term (10–20 years) in coastal counties in Florida. You must choose which plan you would prefer most, by considering each of the various plans and the proposed implementation mechanism within each plan. Your payment listed under each plan would be made through an annual local tax over the next 10 years.

Adaptation Plan	Take No Action	Adaptation Plan A	Adaptation Plan B
Purchase of coastal vulnerable lands and properties for floodplain development	No vulnerable lands or properties are purchased	10% of vulnerable lands and properties are purchased; land is left as a natural floodplain	30% of vulnerable lands and properties are purchased: land is left as a natural floodplain
Storm water management or relocation of underground drainage	No re-plumbing of low-lying drainage	40% of low-lying or underground drainage is relocated	60% of low lying or underground drainage is relocated
Installation of new pump station	No new pump stations are installed	10 new pump stations are installed	40 new pump stations are installed
New regulation for raising elevation requirements for coastal properties	Areas in buildings for residential or commercial use MUST be 4 feet above sea level	Areas in buildings for residential or commercial use MUST be 3 feet above sea level	Areas in buildings for residential or commercial use MUST be 2 feet above sea level
Payment in annual local taxes	$0	$30	$60

Appendix B. Example of a long-term choice card (with matching fund program)

As the global average temperature continues to rise, sea-level rise will continue to accelerate, and its effects will be felt in the long term (30–50 years). As such, the adaptation strategies that worked in the short term may not be feasible or wise solutions for dealing with sea-level rise in the long term. The following question presents several adaptation plans, with various strategies aimed at adapting to increased sea-level rise, in the long term (30–50 years) in coastal counties in Florida. You must choose which plan you would prefer most, by considering each of the various plans and the proposed implementation mechanisms within each plan. Your payment listed under each plan would be made through an annual local tax over the next 20 years. Additionally, local tax revenues raised through your personal contribution will be matched $1 per $1 through funding from the federal government (i.e. for every $1 spent on adaptation, the federal government will commit $1 towards these adaptation strategies).

Adaptation Plan	Take No Action	Adaptation Plan A	Adaptation Plan B
Coastal wetland restoration	No coastal restoration	30% more coastal restoration	50% more coastal restoration
Urban flood manegement	No upgrades to existing canals for better drainage; frequent inland flooding	Only major canals are upgraded to allow for better drainage; 40% reduction in flooding	All canals are upgraded within your county; 60% reduction in flooding
New regulation for raising elevation requirements for coastal properties	Areas in buildings for residential or commercial use MUST be 4 feet above sea level	Areas in buildings for residential or commercial use MUST be 3 feet above sea level	Areas in buildings for residential or commercial use MUST be 2 feet above sea level
Payment in annual taxes	$0	$40	$80

Appendix C. Inundation risk map in Florida (2030–2100)

see Fig. 5.

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