PREFERENCES OF COASTAL RESILIENT DESIGN INTERVENTIONS TO PROTECT RESIDENTIAL LANDSCAPES AGAINST COASTAL HAZARDS

by

KRISTA CAMPOLONG

(Under the Direction of JON CALABRIA)

ABSTRACT

It is evident that sea level rise has a significant impact on coastal cities in the United States, with visible signs such as intense flooding and marsh migration. These responses contribute to coastal squeeze, however coastal adaptations are a solution to make cities more resilient. Unfortunately, coastal cities suffer from implementation of coastal adaptations from a lack of public support and insufficient knowledge about coastal hazard risk. This study evaluated a residential community's preferences for adaptations in response to coastal hazards. I conducted a survey for the Sea Palms West Community to explore their aesthetic preferences for design techniques using discrete choice modeling. The results revealed a preference for living shorelines for the shoreline design and littoral shelf for the pond design. This research may provide better understanding for improved design and management in coastal resilience in residential communities as well as increase public support for coastal adaptation in residential spaces.

INDEX WORDS: Climate Change, Coastal Resilience, Nature-based Adaptations, Residential Design

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CHAPTER 1

INTRODUCTION

Climate change is a global issue devastating our natural habitats, infrastructure, and livelihoods. Several climate change responses are arising as global warming accelerates; one widely documented response is sea level rise (Buchori 2018). Intergovernmental Panel on Climate Change (IPCC) outlines sea level projections and climate change effects in the Sixth Assessment Report (2022). In the United States, the sea level rise (SLR) projections predict that the coast will rise on average 10-14 inches by 2050 (Sweet et al. 2022). The southeast (SE) predicts an additional two-inch rise in ocean levels which is problematic as the SE coastlines are typically low-lying coastlines (IPCC 2022). Globally, some of the visible shoreline consequences include an increase in tropical storm intensity, shoreline erosion, and high-tide flooding (IPCC 2022). Additionally, there are predictions of a decrease in wetlands and other natural systems, water quality, and wildlife and fish biodiversity (IPCC 2022). IPCC details that not only are these devastations negatively impacting our marshes, but they are also catastrophic to humans through the loss of ecosystem services, such as coastal protection from erosion control and shoreline stabilization, as the loss of marshes accelerates (IPCC 2022). Overall, protection of our natural systems, like tidal wetlands, is critical in reducing the impacts of sea level rise.

The UGA Marine Extension and Georgia Sea Grant describes Georgia to be home to the second largest amount of salt marshes in the US, which is approximately 500,000 acres. In fact, Georgia's salt marshes account for one third of all the East Coast's marsh systems. These ecosystems are the areas between barrier islands and mainland, which holds brackish water that hosts an abundance of wildlife and plant species. In Georgia, the tidal prism rises 6-8 feet, twice a day, which inundates the tidal marsh with seawater. The marsh system is complex, which is the reason for researchers to divide the systems into ecological zones. The ecological zones are characterized by the time and depth of the tides during the day, which is mainly due to the differences in elevation on the shoreline. The following ecological zones are found on the Georgia marsh shoreline: Levee Marsh, Low Marsh, High Marsh, Marsh Border, and Transition Zone (Marine Extension and Georgia Sea Grant 2022). The following figure provides a visualization of the profile of a salt marsh (Sherpa Guides 2020).

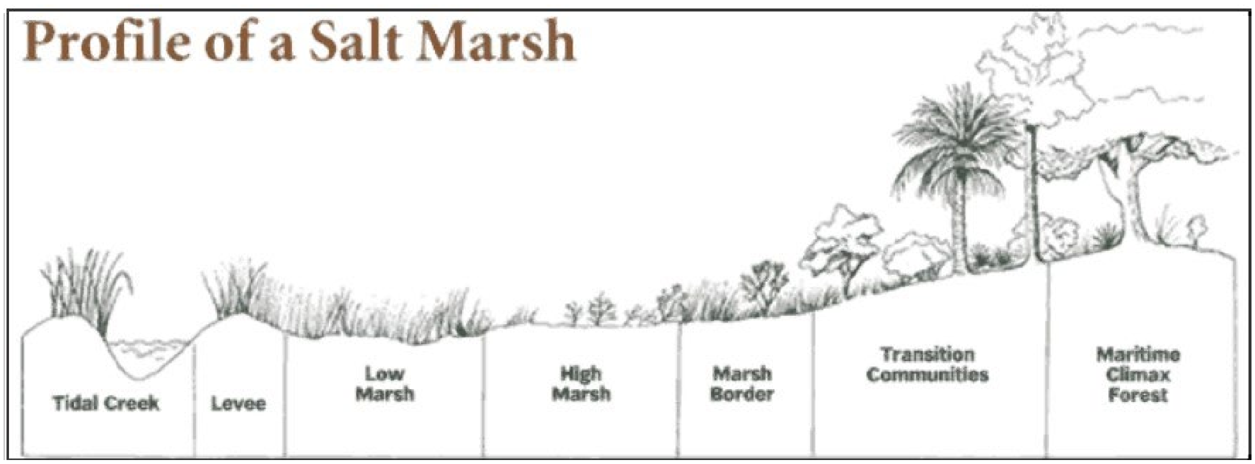


Figure 1: Profile of a Tidal Marsh adapted from Sherpa Guides (Sherpa Guides 2020).

The levee marsh is the zone on the shoreline or banks of the tidal creeks. It is consistently under marsh water and is host to smooth cordgrass (*Spartina alterniflora*) (Davis et al. 2015). The flow marsh is the zone adjacent to the marsh levee, in that it consists of marsh mud and vegetation. The tide is constantly changing in this zone, therefore only a few plant species, which include smooth cordgrass and black needle rush (*Juncus gerardii*), can withstand these harsh conditions. The high marsh is at a higher elevation; therefore, it is rarely inundated with marsh water. The soil is sandier with a lower salinity compared to the soil in the low marsh, so there are more plant species that can survive in this zone. Some of the plants present in this zone include smooth cordgrass, glasswort (*Salicornia*), and saltwort (*Batis maritima*). In addition, the high marsh can consist of barren sandy areas, 'salt pans', that are characterized by high concentrations of salt. The marsh border is rarely flooded by tidal water, so it hosts a multitude of plant species such as marsh elder (*Iva annua*), cedar trees (*Juniperus silicicola*), etc. Lastly, the transition zone is the ecotone for the marsh system and maritime forest, therefore the vegetation is woody. Cabbage palms (*Sabal minor*) are an indicator of this ecological zone (Marine Extension and Georgia Sea Grant 2022).

Overall, the entire marsh system is 'habitat for specific organisms,…function as feeding grounds for terrestrial vertebrates, as a buffer to protect against coastal storm surge, and as a natural filtration system to improve water quality, transform nutrients, and retain sediment' (GADNR 2022). Because this study focuses on protecting the landscape and infrastructure from coastal hazards, preservation of tidal marshes is ultimately the best measure for coastline protection. Unfortunately, marsh systems are vulnerable due to coastal squeeze, which is 'the loss of coastal habitat in front of landward boundary and the low water mark migrating landward', predominantly due to shoreline hardening. With the development along the shoreline, the coastal marsh cannot naturally migrate, which contributes to the loss of this important ecosystem (Polk et al. 2022). Therefore, there must be other adaptations to aid in shoreline protection.

Adaptations techniques to reduce the effects of sea level rise are all part of the larger initiative of coastal resilience. Coastal resilience is the ability for natural systems and the built environment to 'bounce back' after coastal hazards (Nordenson et al. 2018). There are three categories that serve to characterize resilience adaptations to the landscape to reduce the risk of coastal hazards: Green Infrastructure, Gray Infrastructure, and Hybrid Infrastructure. Green infrastructure uses natural elements such as vegetation, oysters, and biodegradable materials to stabilize shorelines, while gray infrastructure uses hard materials like steel, wood, plastics, and metals. Hybrid infrastructure is a heterogeneous mixture of both natural and hard materials to accomplish the same objective of reducing erosion and creating resilient shorelines (Waryszak 2021). All these coastal resilience measures have varied advantages and disadvantages; therefore, site specific design must drive which adaptation will be most successful (Narayan 2016). However, with the abundance of adaptations available, there is another factor that may drive designers' choices: aesthetics.

In the past, research connecting ecology and aesthetics was limited, as designers focused on each exclusively of each other. However, in the last few decades, ecology and aesthetics are connected through theory and research (McHarg 1969; Paul H. Gobster 1999; Howett 1987; P. H. Gobster et al. 2007; Nassauer 1995a). Natural systems are rich in vegetation, originality, and scenic viewsheds, all of which high in visual appeal. Ian McHarg describes, 'nature itself produced the aesthetic' (1969). Joan Nassauer's research suggests that designers can introduce ecological design in landscapes when following the 'cues for care,' which include stewardship, naturalness, and neatness (Nassauer 1995b). When ecologically healthy landscapes look neat and more manicured, the natural landscape portrays a level of stewardship for the land which translates into the publics' care for the environment. Overall, aesthetics is fundamental in designing natural ecosystems where humans reside, as it will increase stewardship and care in natural resources, particularly in their own communities.

In spring 2020, Sea Palms West Community Association (SPWCA) contacted University of Georgia Warnell School of Forestry and Natural Resources to develop a plan to convert their newly inactive nine-hole golf course into passive greenspaces. Their initial goals were to maximize ecosystem health, recreational use, and property value. To minimize costs, the greenspace remains relatively similar apart from different mowing regimes for exotic Bermuda grass. Furthermore, the concrete golf cart paths throughout the course aged over time, resulting in cracks, so the HOA repaired the concrete pathways as needed to allow recreational use of the passive greenspace. During spring 2019, a minimal management plan was created, and work on the plan began shortly thereafter. As soon as their plan objectives were achieved, SPWCA requested a master plan to transform the passive greenspace into a recreational park. I wanted to investigate recreational design alternatives that can satisfy the needs of the community.

However, this site presented a unique challenge due to its proximity to the marsh, posing a challenge for converting this defunct golf course into a passive greenspace. The projected marsh progression, as a result of sea level rise, will cause significant damage to existing infrastructure, such as residential homes, roadways, and clubhouses, as well as passive greenspace. Through research in coastal adaptations, I found copious knowledge about adaptation strategies to make cities more resilient, however there is a lack of implementation of these projects (Gibbs 2016; Stephens et al. 2020; Wise et al. 2013). This is likely due to a lack of advocacy from the public to implement these adaptations, primarily resulting from a lack of public support (Bowden et al. 2019; Moser 2014; Singh et al. 2017; Leiserowitz 2006; Mallette et al. 2021). Participatory design increases public support, which ultimately drives individuals to adopt coastal adaptation projects in their communities (Mallette et al. 2021, Dumaine 2015; Bongarts Lebbe et al. 2021; Alexander et al 2011; Tompkins 2007).

This research studies the aesthetic preferences of residential communities for different adaptation techniques, given multiple factors such as cost, resilience, flood risk, water quality, and wildlife habitats. By understanding the aesthetic preferences of residential communities, landscape architects and civil engineers can build public support of coastal adaptation through public participatory design (Landry et al. 2022; Dumaine 2015; Tompkins 2007). Participatory design, through understanding the communities' preferences, can increase public support which will lead to more implementation (Mallette et al. 2021, Dumaine 2015; Bongarts Lebbe et al. 2021; Alexander et al. 2011; Tompkins 2007). Additionally, understanding the elements that influence an individuals' preference helps practitioners to see the values, experiences, and motivators of their community. Therefore, researching the drivers that influence individuals' preferences and support for coastal adaptation can build support through knowledge of the public's risk perceptions and values (Singh et al. 2017; Leiserowitz 2006; Dumaine 2015; Tompkins 2007; Mallette et al. 2021). This will help to foster policy and education to increase public support from a viewpoint that respects the social values of the community. It can lead to collective learning and education through public outreach.

This thesis studied the aesthetic preferences of the Sea Palms West residential community to determine their attitudes toward different resiliency design alternatives through discrete choice modeling. Discrete choice experiments are successful in analyzing individuals' preferences of 'products' that each contain several attributes such as cost, flooding risk reduction, wildlife habitat, and water quality (Champ 2017; Landry et al. 2022; Dumaine 2015). Each of the attributes has several levels at which the attribute can be present. For example, within the cost attribute, the different levels may be $10, $15, or $20. Discrete choice experiments present respondents with the option to choose one scenario from several choices, each scenario containing the attributes with a varied value. The discrete choice experiment modeling will provide all the individuals with a specific number of questions with different scenarios to generalize on which scenarios (products, attributes, and levels) are most favorable to the respondents (Champ 2017). The study method employs discrete choice modeling in a web-sourced survey and statistical analysis to analyze the communities' preferences for coastal resilient adaptations.

Community driven design in nature-based projects can evoke a sense of stewardship to the land, as it incorporates the individuals' values and preferences in the design solution (Puskás et al. 2021; Arnstein 2019). Puskas et al. (2021) outlines that higher community participation can improve the project's success through the eyes of residents, which can streamline design development in several ways (Puskás et al. 2021). Community driven design can increase coastal resilience literacy among the public which is essential for improving coastal resilient adaptations in their local community. Residential communities are likely to implement more CR if the projects are funded through SPLOST and grant funding. Special Purpose Local Option Sales Tax (SPLOST) can be implemented in coastal cities to increase funding for coastal resilient infrastructure (ACCG 2016). Next, this research study can be influential for designers and ecologists to implement adaptations that are favorable in communities which increases public support. Understanding communities' preferences helps to implement design adaptations that will satisfy the community as well as achieve the objectives of the designer.

Research question

This study addressed the following research question to help determine the preferences of coastal resilience design:

What are the preferences of a residential community for coastal resilience design interventions, given multiple factors such as cost, storm flood risk, high tide flood risk, water quality, and wildlife habitat quality?

Organization

I organized this thesis study into four sections: literature review, methods, discussion, and conclusion. The literature review addressed the following research areas relevant to my research study: climate change projections and responses, coastal resilience, grey infrastructure, green infrastructure, hybrid infrastructure, aesthetic preferences, assessing adaptation preferences, discrete choice modeling, statistical analysis, and nonresponse in surveys. These areas of research helped me focus my study to address the problem statement: lack of coastal adaptation in residential communities. Then, using a tailored design method, I surveyed communities to assess their opinions on coastal adaptations using discrete choice modeling (Dillman, Smyth, and Christian 2014). The results were analyzed through count analysis, fit modeling, logit modeling, and marginal rate of substitution analyses. Using the results, I discussed my study's findings. As a result, I emphasized the significance of the study to practitioners, policymakers, educators, and so on. Lastly, I outlined further research areas to build knowledge in coastal adaptation.

Outcomes

The concept of coastal resilience is relatively new, having emerged in response to the effects of sea level rise caused by climate change. In recent decades, designers, policymakers, and outreach professionals focus their research on design interventions that create resilient public spaces and infrastructure. There is a lack of research in residential communities, particularly their preferences for design adaptations and what influences their preferences. This study can assist in providing knowledge of resilient adaptation preferences and the willingness to pay for adaptations to increase public support for coastal adaptations. Additionally, this knowledge can benefit policymakers and practitioners in providing knowledge of societal values and drivers for coastal adaptations. Lastly, this methodology can serve as a framework for practitioners to employ in their communities to engage with the community through participatory design.

Limitations and delimitations

The study surveyed the Sea Palms West Community residents in St. Simons, GA. A limitation of the study was a poor response rate. The breakoff rate was very high. Specifically, the discrete choice experiment (DCE) questions had poor completion rates. Additionally, many individuals opened the survey and exited before completing a question.

One of the delimitations of the study was the sample size and geographic region. This study was conducted in a small population in a relatively affluent area adjacent to the marsh. Broadening the sample population would provide a wholistic perspective on preferable design interventions within the field of coastal resilience. A second delimitation of the study was the site-specific scope. The adaptations chosen for the study were limited to design interventions that were appropriate for the Sea Palms West Community retired golf course. There are several other coastal resilient adaptations that could be included in further studies to gain a better understanding of residential community preferences.

CHAPTER 2

LITERATURE REVIEW

With the abundant knowledge of climate change, coastal resilience is emerging concept to describe the adaptation of coastal areas to the damaging effects of climate change (Sinay and Carter 2020; Polk et al. 2022; Timmerman et al. 2021; McGuiness et al. 2019; IPCC 2022; Nichols et al. 2019). Coastal resilience adaptations reduces the effects of coastal erosion, storm surge, extreme flooding, and marsh migration by making the landscape more 'resilient,' or the ability to bounce back (Nichols et al. 2019; Nordenson et al. 2018; Sinay and Carter 2020; IPCC 2022). Therefore, to ensure resilient coastlines in coastal areas, coastal resilient action must be taken to address climate change effects. Examples of coastal resilience adaptations are bulkheads, seawalls, living shorelines, levees, managed retreat, raising homes above the flood zone elevation, and more (Arkhurst et al. 2022; Nordenson et al. 2018; Gittman et al. 2015; Small et al. 2016).

With the growing knowledge of coastal adaptations, there must be adoption of these projects to drive resiliency in coastal communities. Public support is essential to increase implementation of coastal adaptations in coastal cities (Gibbs 2016; Stephens et al. 2020). Through participatory design, practitioners can build public support for adaptation projects by assessing individuals' preferences as well as values and perspectives of risk surrounding sea level rise (Singh et al. 2017; Leiserowitz 2006; Dumaine 2015; Tompkins 2007; Mallette et al. 2021). Discrete choice modeling can assess individuals' preferences through presenting several design scenarios given several attributes (Champ 2017; Dumaine 2015; Landry et al. 2022). A web-based survey can host discrete choice experiments and multiple-choice questions to gauge the communities' preferences and risk perceptions. The tailored design method can fine-tune the questions through formatting, organization, and quality control to ensure a successful survey (Dillman, Smyth, and Christian 2014). Lastly, studying the challenges in response rates in surveys provided insight on the areas of further research (Bosnjak and Tuten 2001; Peytchev 2009).

Climate Change Projections and Responses

Climate change is the defined by long-term changes in temperature, natural disasters, and storms (IPCC 2022). Since the 1800s, human activities have played a major role in climate change, in particular, the burning of fossil fuels, which increases the greenhouse gases in the atmosphere (IPCC 2022). One of the most visible consequences of climate change is rising sea levels. As the rate of carbon emissions and GHG increases, sea level rise (Buchori et al. 2018) and marsh migration will rise as well. One of the main catalysts for sea level rise is the melting of glaciers and ice caps which increases the volume of water in oceans. The second contributor to SLR is thermal expansion of water which increases the size of water molecules (IPCC 2022). The Intergovernmental Panel on Climate Change (IPCC 2022) is a working group that studies climate change in all capacities such as climate change projections, consequences, and adaptation scenarios (IPCC 2022). Their most recent publication details the current, global climate change scenarios, as well as the specific projections for the Southeast.

IPCC outlines a 1.5° C (2.7° F) increase globally, which causes many coastal consequences such as sea level rise (IPCC 2022). Sea level rise is rapidly affecting the coastline and marsh line, and in fact, data demonstrated that the global sea level increased four to five inches from 1900 to 1990. The rate of sea level rise during this time was an increase of one inch every 20 years. However, within the years of 1990-2015, there was a sea level rise of three inches which is a rate of sea level rise of one inch every 8.333 years (NOAA 2017). The current SLR projection for 2050 in the Southeast specifically is between 10-14 inches (NOAA 2017). Therefore, it is evident that the rate at which sea level rises is increasing dramatically. In fact, the current SRL projection is a one to seven ft increase by 2100 which could dramatically change the coastal landscape in the southeast due to many coastal hazard consequences (NOAA 2017).

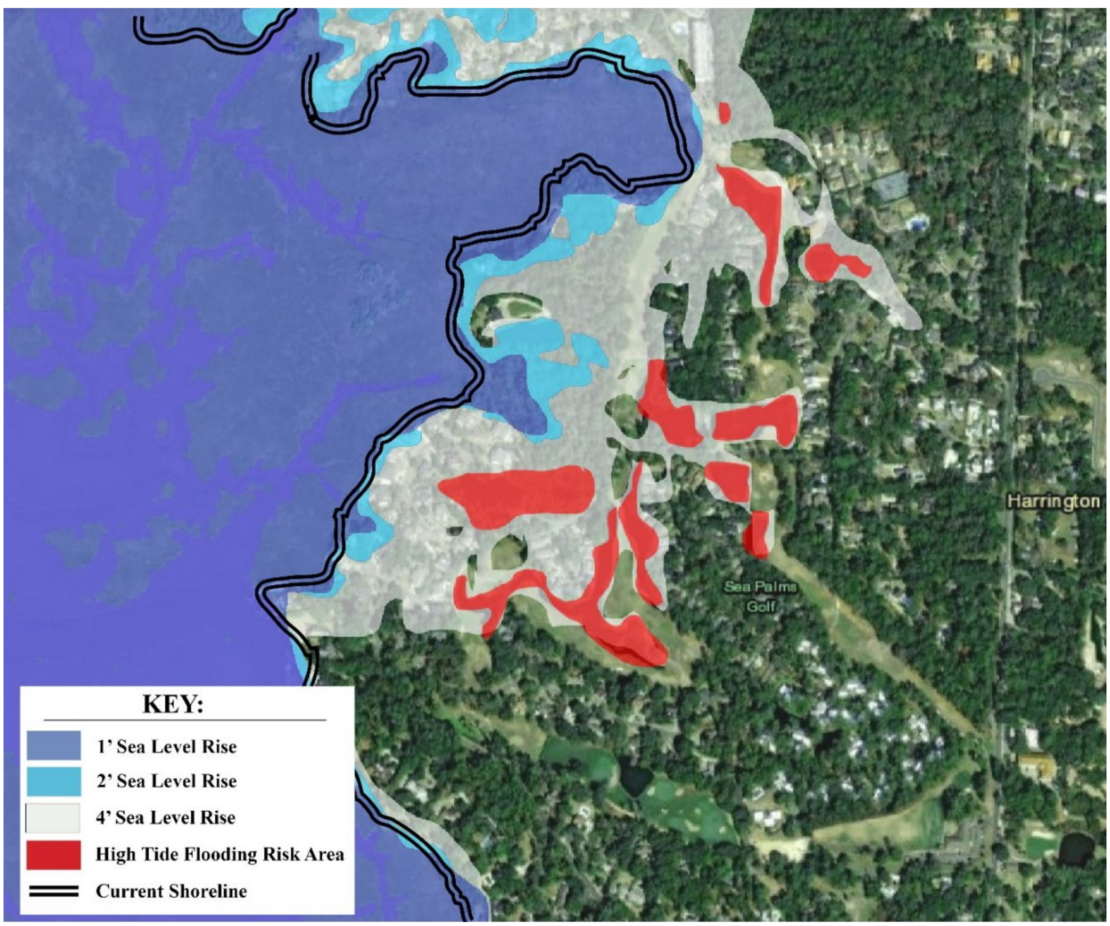


Figure 2: Sea level projections on the site for sea level rise scenarios of 1', 2', and 4' rises and high tide flooding risk areas (NOAA 2022a)

Currently, the consequences of sea level rise are seen with an increase of flooding, erosion or loss of beaches and tidal marshes, storm intensity, and frequencies of hot and cold extremes (IPCC 2022). Unfortunately, the rate at which these consequences intensify will only increase as the levels of climate change increase, as seen with the current projections. Unfortunately, ecosystem health is decreasing due to climate change effects. One climate change consequence that is devastating the coast is marsh migration, which can be detrimental in areas where shoreline hardening has occurred. Coastal squeeze is a term coined to describe 'the loss of coastal habitat in front of landward boundary and the low water mark migrating landward' which occurs due to shoreline hardening (Polk et al. 2022). The low and high marsh are extremely vulnerable to SLR because higher levels of sea water inundate the marsh when sea levels rise. This will contribute to changes in the niche characteristics of the marshlands, such as soil pH, salinity, and nutrients, that make up low and high marshes (Baptist et al. 2021). These effects will ultimately degrade the ecosystem health of our coastlines, such as a decrease and loss in plant and wildlife biodiversity and water quality (IPCC 2022). Furthermore, climate change is damaging our infrastructure, which is directly a result of the reduction of available marsh and other coastal hazards (Baptist et al. 2021).

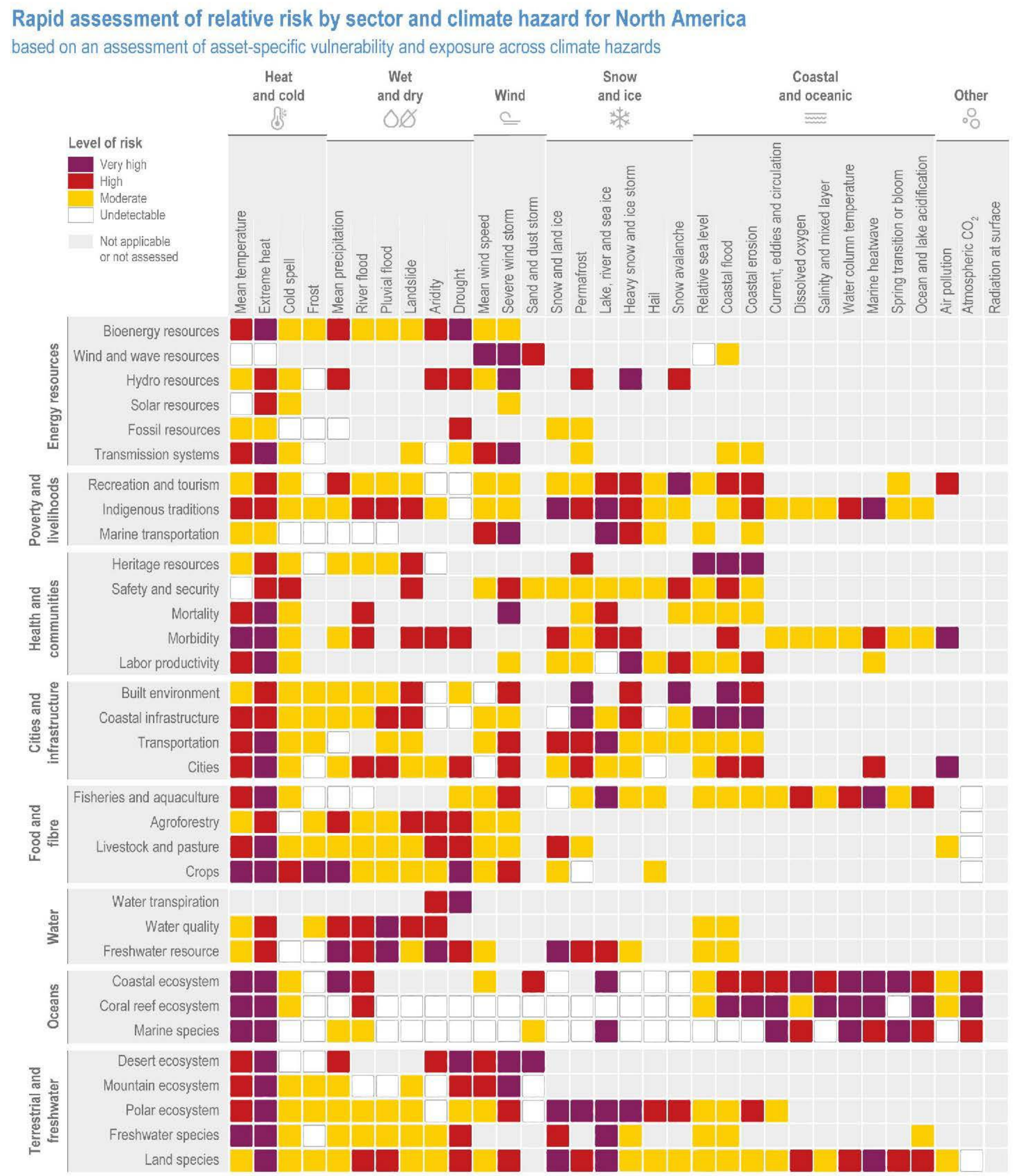


Figure 1: Rapid assessment of relative risk by sector (*y*-axis) and climate hazards (*x*-axis) for North America based on an assessment of asset-specific vulnerability and exposure across climate hazards (see SM14.3 for methodological details). For each unique combination, the hazard-by-sector risk was ranked as very high (very high risk and *high confidence*), high (significant impacts and risk, *high to medium confidence*), medium (impacts are detectable and attributable to climate change, *medium confidence*), low or not detected (risk is low or not detectable). Blank cells are those where the assessment was not applicable or not conducted. {Figure 14.11}

Figure 3: IPCC highlights North American climate change consequences, such as coastal erosion, relative sea level, and coastal flood, and their effects on their risk on assets like cities and infrastructure, health and communities, water resources, ocean health, and terrestrial and freshwater health. Within cities and infrastructure, there is high levels of risk for flooding, erosion, and sea level rise for coastal infrastructure (IPCC 2022).

Sea level rise responses degrade the existing infrastructure such as roads, housing, stormwater management, etc. (IPCC 2022). Coastal squeeze is to be blamed for this degradation, as the loss of marshes directly affects the coastline. Marshes are important ecosystems on coastlines as they reduce wave attenuation, storm surge, and reduce flooding significantly (Shepard et al. 2011). Therefore, the structural integrity of infrastructure will decrease which inevitably contributes to disaster recovery costs. For example, Superstorm Sandy caused the cities of New York and New Jersey a combined cost of $62.3 billion in recovery costs excluding adaptation efforts (Abel et al. 2012). Fortunately, there are several ways to reduce coastal hazard risk due to SLR.

Coastal Resilience

Landscape architects, policy makers, and other environmental professionals must address the effects of climate change, through adaptation efforts. Because climate change occurs due to greenhouse gas accumulation in the atmosphere, global efforts to reduce GHG by reducing emissions and increasing carbon sequestration can reduce the rate of climate change (IPCC 2022). The reduction of carbon emissions and other global greenhouse gas emissions will lessen the damage of climate change on the coast significantly compared to any other mitigation measures (Neumann et al. 2015). However, this study focuses on a site scale as opposed to a global or national scale, so different efforts must be studied to reduce the coastal hazards. Subsequently, adaptation efforts that this study focuses on are on coastal hazard risk reduction, which is within the greater global initiative of coastal resilience. Coastal resilience refers to the ability to 'bounce back' from coastal hazards like storms, floods, and sea level rise. The current framework for coastal resilience outlines three categories of response to climate change: retreat, accommodate, and defend (CoastAdapt 2017).

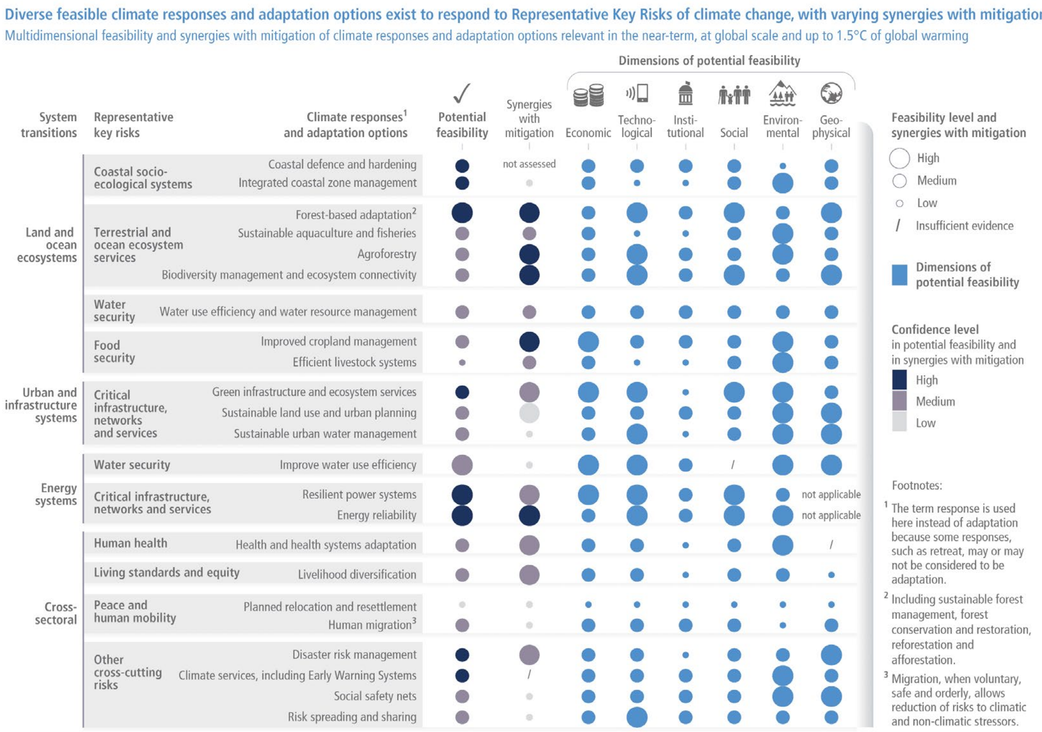


Figure 4: IPCC specifies the feasibility level (within different organization sectors) and mitigation success of climate responses/adaptations, such as shoreline hardening, agroforestry, and green infrastructure (IPCC 2022).

Managed retreat is the movement of communities, structures, and/or assets to less vulnerable areas, particularly not on the coast, in response to climate change effects (Sinay and Carter 2020). This adaptation eliminates the threat of coastal hazard related infrastructure damage; therefore it is the most 'successful' in risk prevention (Freudenberg et al. 2016). Evidently, most coastal residents find this to be the least desirable adaptation effort for several reasons: relocation costs, attachment to place, cultural heritage loss, and perceptions of relocation destination. In fact, the cost for implementing managed retreat averages between \$10,000-\$100,000 per person, varying among living costs, individuals' assets, and destruction of shoreline hardening (Hino 2017). While managed retreat is unfavorable for most individuals, it can be favorable for different demographic groups (Kenneth and Tammy 2021).

Managed retreat is considered the most sustainable option in reducing environmental gentrification among low income and people of color demographic groups. When other adaptation efforts are deployed such as defense or accommodating interventions, real estate becomes more expensive on the coast, creating disparity and inequity in coastal cities. Communities with increased funding can afford to protect their landscape against coastal hazards, which consequently drives up income taxes, insurance premiums, etc. Individuals with less money, who have cultural significance to the area, are forced to leave the area. Research has suggested that this low income demographic disproportionately affects black individuals and people of color which contributes to gentrification (Kenneth and Tammy 2021). Despite these challenges, many inhabitants prefer to stay and adapt to their environment, rather than leave, mainly due to social factors such as being comfortable with their community relationships (Buchori et al. 2018). Because managed retreat is unfavorable in many scenarios for coastal communities, there are other interventions that focus on adapting the existing infrastructure and landscape to protect against coastal hazards.

The 'accommodate' category refers to the adaptation of existing infrastructure to reduce the risk of flooding, sea level rise, and marsh migration from storm surges. Examples of accommodating current infrastructure include raising homes above the flood risk height as well as elevating roads and bridges to reduce the risk of water inundation (Sinay and Carter 2020). While this is an effective strategy to mitigate risk from climate change, the focus of this study primarily aims to emphasize changes to the landscape, which follows the 'defend' framework of climate change adaptation.

The ‘defend’ category addresses protecting the area from storm surge, intense storms, flooding, etc. with defense adaptations that reduce erosion and harden the shoreline (Sinay and Carter 2020). In this study, there is a focus on six adaptation techniques that will make the landscape more resilient to the effects of climate change: bulkheads, living shorelines, horizontal levees, redirected floodwater into ponds with littoral shelves, redirected floodwater into ponds with floating wetlands, and marsh restoration. The defenses outlined above are specifically applicable to the site, although other successful defenses have been developed for other landscapes, like thin layer placement, breakwaters, beach renourishment, etc. (Sinay and Carter 2020). Within the framework of coastal resilient adaptations, there are three main distinctions that professionals can use as defenses for the landscape: grey infrastructure (hard structural defenses), green infrastructure, and a hybrid of both (Waryszak et al. 2021; Bilkovic et al. 2017).

Grey Infrastructure in Coastal Resilience

Grey infrastructure is described to be infrastructure with the use of hard materials such as concrete, steel, wood, etc. to engineer solutions for stormwater management, including coastal resilience measures. For instance, a wooden or steel bulkhead is a prime example of grey infrastructure. A bulkhead is a seawall, typically built from wood, steel, or other hard materials, that protects the shore or marsh from erosion (National Research Council 2014). Bulkheads are not resilient when confronted with intense storms such as hurricanes and increased flooding because they are comprised of hardened, abiotic structures in contrast to nature-based solutions (Gittman et al. 2015). In addition, they disrupt habitats on shorelines which contribute to decreased species richness and biodiversity (Gittman et al. 2015). Particularly, bulkheads disrupt the land and water connection which is problematic as marsh migration continues to increase as the rate of SLR increases. Essentially, bulkheads act as barriers to the natural migration of marsh which catalyzes the 'coastal squeeze' effect, which reducing the tidal marsh ecosystem that is essential for hurricane protection (Polk et al. 2022). Cost estimates for hardened shorelines, such as bulkheads, range between $450-1,000 per linear foot which is significantly more than nature-based solutions like living shorelines (NOAA 2020). Bulkheads are becoming more advanced, as seen with the Alki Coastal Erosion Control Project in Seattle, WA (Army Corps of Engineers 2019).

Figure 5: Image of Bulkhead adapted by First Coastal (First Coastal 2016)

The U.S Army Corps of Engineers (USACE) is proposing a coastal bulkhead in the Puget Sound in response to the inadequacy of shoreline stabilization of their existing seawall, which is projected to fail by 2023. USACE is partnering with Seattle Parks and Recreation Department to create a new bulkhead to reduce coastal storm damage while increasing recreation, through proposed walking paths with wildlife viewing areas. Wildlife viewing areas are possible due to the reduction of environmental impacts that the proposed bulkhead construction will bring. This alternative is most favorable because of environmental impact reduction, cost reduction, and the maximization of coastal damage reduction. The entire bulkhead area is 500 linear feet of shoreline. The estimated project cost is $2.29 million, which is 65% federally funded (Army Corps of Engineers 2019). Overall, this proposed project is estimated to be monumental in reducing coastal hazards in the West Seattle area. While grey infrastructure is successful, green infrastructure is favorable for coastal resilience measures due to cost effectiveness (Reguero et al. 2018).

Green Infrastructure in Coastal Resilience

Green infrastructure is infrastructure that utilizing "plant or soil systems, permeable pavements or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce the amount of flow into sewers and surface water" (EPA 2020) (Gittman et al. 2015). Examples of these nature-based structures that fall into the coastal resilience adaptation techniques include marsh restoration, wetland restoration, and littoral shelves around existing waterways to reduce erosion.

In terms of cost-benefit ratios, marsh restoration measures are classified to be the most cost-effective and offer the most risk reduction when compared to other adaptation measures (Reguero et al. 2018). In fact, over $8 million of avoided damage costs were calculated where natural habitats were present during Hurricane Sandy. The avoided damage costs estimated with the 2050 SLR scenario are $32 million where natural habitats are present (Rezaie, Loerzel, and Ferreira 2020). In addition, existing marshes and restored marsh areas provide an array of ecosystem services, including reduction of wave attenuation. Studies describe marshes as more ‘durable and may protect shorelines from erosion better than bulkheads in a Category 1 storm (Gittman et al. 2014). Ecosystems processes that protect against coastal hazards include ‘increased bed friction, local shallowing of water, sediment deposition and building vertical biomass’; all these processes increase wave attenuation and change the shore profile and elevation to be more resilient against intense storms, flooding, and erosion. In terms of wildlife habitat performance, some of the ecosystem services described above include wildlife habitat, fisheries provision, nutrient cycling/water purification, carbon sequestration, and recreation and tourism (Morris et al. 2018).

Figure 6: Image of Marsh Restoration adapted from SumCo Eco-Contracting (SumCo Eco-Contracting 2016)

An example of marsh restoration project is the Elkhorn Slough restoration project that was proposed in 2014 with a completion date in 2025. The project intended to restore the 50% loss of tidal marshes in the Elkhorn Slough system, which was due to tidal flooding from harbor construction and erosion from widening and deepening creeks. The restoration site was 104 acres, which would complete through phases for funding and reduction of ecological damage. The implementation cost is estimated to be around $7.5 million with the first phase costing around $4.2 million. Materials, such as sediment, carbon sequestering marsh plants, and temporary berms and culverts for construction, are used to complete this project. Overall, the general goals for the project include reducing flood risk, increasing wildlife habitat, increase recreational fishing, and carbon sequestration (ESA 2014). Marsh restoration is a prime example of the ecosystem services that green infrastructure provides to communities.

In addition to marsh restoration, littoral shelves are an example of green infrastructure to help reduce erosion and mitigate high tide flooding. A littoral zone is characterized as a sloped shelf around a pond or lake that is heavily planted with native wetland plants. Littoral shelves can be described as small wetlands, which are important elements to reduce erosion and maintain shoreline stability due to the native plants rooted deeply into the soil. Additionally, they provide habitat and forage for wildlife, directly increasing ecosystem health (Solitude Lake Management 2022). The ponds in the golf course were continuously exposed to pesticides and fertilizers which negatively impacted the oxygen levels and basic chemistry of the water (King 2006). Therefore, water quality treatment would be beneficial on this site. Fortunately, littoral zones can balance oxygen levels and other elements in the water. In addition to improving water quality, littoral shelves make up the water edge with native vegetation such as Pickerelweed, Blue Flag Iris, Fragrant Water Lily, and Golden Canna. These perennials bloom throughout the year with showy flowers, which increase the aesthetic appeal of the landscape (Solitude Lake Management 2022). Lastly, littoral shelfs are an inexpensive option to mitigate erosion with the average price around $63-113 per linear foot (NOAA 2020).

Figure 7: Image of Littoral Shelf on Gulf Course adapted from Solitude Lake Management (Solitude Lake Management 2022)

Duke University Water Reclamation Pond falls within the littoral shelf adaptation in terms of erosion control. While this project site is not coastal, the project site is a degraded stream that is part of the Cape Fear River basin watershed, which comprises 35% of impaired streams. The stream water in this watershed is used for drinking water, which is one of the main reasons why this restoration project was necessary. In addition to increasing potable water, reducing flooding impacts is a main objective for completing this project. Overall, the Duke University Water Reclamation Pond project cost approximately $11.5 million to plant the littoral zone with the 5.5 acres pond site. The project consisted of planting over 30,000 individual plants, all of which were native, and constructing multiple walking paths for recreation and education. Monitoring of the completed site concluded a significant decrease of downstream nutrient loads and sediment, which describes a reduction in erosion (Hogge and Pinto 2020). In summary, littoral shelf ecosystems provide a multitude of performance benefits, including erosion control, which can be used in climate change adaptation.

Figure 8: Image of the Duke University Water Reclamation Pond Littoral Shelf adapted from Nelson Byrd Woltz (Woltz 2015)

Figure 9: Illustrative Plan for the Duke University Water Reclamation Pond Littoral Shelf adapted from Nelson Byrd Woltz (Woltz 2015)

The last adaptation that falls within the ‘green’ infrastructure category is floating wetlands. Floating wetlands are artificial platforms with material that native wetland plants grow through where the water level is too deep or fluctuating for plants to naturally grow. They float on the surface of the water, despite periodic rises and falls in the water levels, which make them advantageous for flooding events. Floating wetlands reduce wave energy in ponds which help reduce erosion and damage to surrounding areas. Additionally, they can improve water quality and balance oxygen levels in the water. They provide habitat for an abundance of species of wildlife and microbes that can purify the water. Floating wetlands are planted with emergent, native perennials like those in littoral zones, therefore, the aesthetics of the pond increase and provide attractive views in the community. Lastly, the cost is comparable to littoral zones with additional costs of the foam and plastic floating material, making it less cost effective (Powell 2012). While the concept of floating wetlands is relatively new in literature, there are several complete projects that are past the monitoring phase including the Chicago Riverwalk floating wetlands (Hanson and Callone 2019).

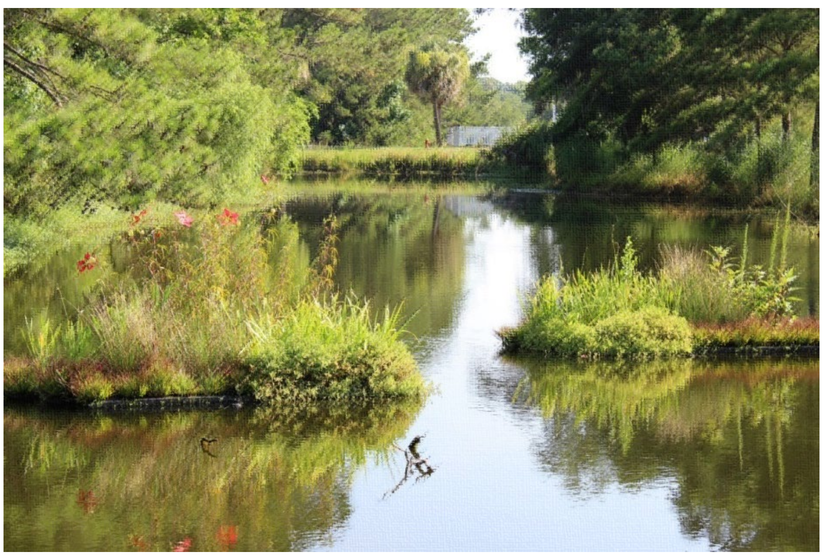


Figure 10: Image of Floating Wetland adapted from Guinn Wallover (Wallover 2022)

Phase two and three of the Chicago Riverwalk project features 1,590 sf of floating wetland in the 'Jetty' area, which comprised of suspended walkways. The Chicago River was once a marshy wetland, however, barge and commercial boating boomed during the Industrial Revolution which resulted in hardening the banks with grey infrastructure. Shortly after, the city was experiencing stormwater drainage problems, which led to the creation of the Riverwalk project.

Therefore, enhancing the river to be a 'highly flood-resilient urban landscape' was one of the projects' main goals. Additionally, the floating wetlands provided excellent habitat for fish and other aquatic wildlife, while improving water quality and sequestering carbon (Hanson and Callone 2019). As a result, floating wetlands make resilient landscapes, reducing flood inundation, making them successful in reducing coastal hazard risks.

Figure 11: Rendering of the Chicago Riverwalk's Floating Islands adapted from Martin Ecosystems (Martin Ecosystems 2017)

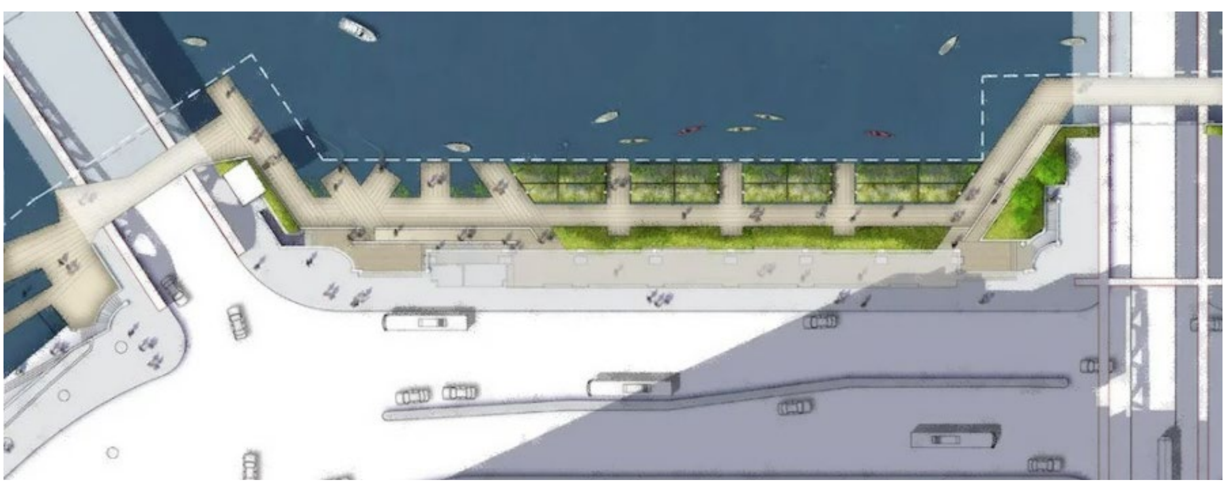


Figure 12: Illustrative Plan of the Chicago Riverwalk's Floating Islands adapted from Martin Ecosystems (Martin Ecosystems 2017)

Hybrid Infrastructure in Coastal Resilience

Living shorelines are a prime example of hybrid adaptations. Living shorelines refers to a footprint that is largely comprised of nature-based materials, such as natural vegetation or other living things. The soft elements can be found either alone or in conjunction with a hard structure like oyster reefs, rock sills, or wood anchored to the shoreline. Living shoreline not only stabilizes the shoreline, but also reduces erosion and enhances coastal resilience by providing ecosystem services such as habitat (Harris 2021; Davis et al. 2015). In fact, living shorelines are found to be more resilient than hard structural solutions because of the connection between water and land. Living shorelines can adapt and migrate as SLR increases, which reduces coastal squeeze (Polk et al. 2022). In addition, living shorelines, as well as marsh and wetlands restoration, are the most cost-effective option for climate change adaptations (Reguero et al. 2018). The average cost for living shorelines range from $1,000 to $2,000 per linear foot (SAGE 2015). Living shorelines are found throughout the United States to protect the shoreline from coastal hazards.

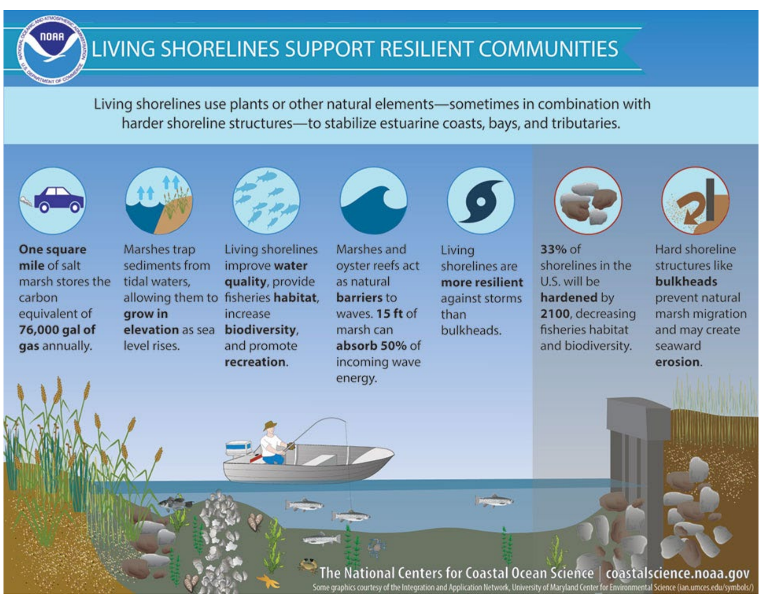


Figure 13: Illustration of Living Shoreline Benefits (NOAA 2022b)

An example of a living shoreline is the Sunnyside Road living shoreline in Oyster, VA. The Sunnyside Road Living Shoreline project occurred in Oyster, VA and comprised of 16,000 sf of marsh plants and oyster shell bags and 450 linear feet of rock sill. This project was initiated to replace a degraded bulkhead and to provide the community with a successful living shoreline demonstration. The Nature Conservancy, as well as several other governmental agencies such as NOAA, U.S. FWS, and more, worked on creating and implementing the project in 2010 (Belcher et al. 2019). Due to its success for shoreline protection, the site is a great adaptation to mitigate coastal vulnerability.

Horizontal levees are steep-sloped, hardened structures, typically vegetated, that are situated between coastal habitats, like coastal marshes, and existing infrastructure that needs protection from climate change effects. This design intervention is an example of hybrid infrastructure to reduce the risk of coastal hazard. Its role comprises of erosion control and reduction of shoreline flooding and wave attenuation. Implementation and maintenance costs associated with horizontal levees are about 40% less than traditional waterfront levees. This adaptation measure is increasingly popular because it not only reduces erosion of essential infrastructure, but it often increases recreational opportunities. Often, horizontal levees are built with pedestrian and bicycle pathways on top of the hardened structure. One consideration for this solution is levees perform best when used in conjecture with healthy marsh ecosystems, therefore, marsh restoration may be needed on sites where levees are suitable (NRC 2022). Because these projects are relatively large, counties or larger governmental groups work to implement these projects, such as the Oro Loma Sanitary district (Warner 2015).

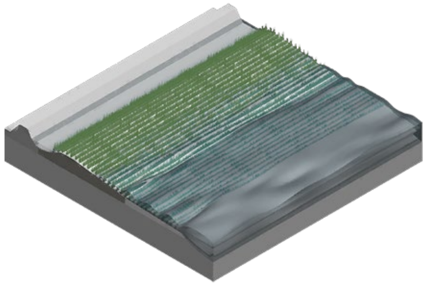


Figure 14: Axon Visualization of a Horizontal Levee adapted from Naturally Resilient Communities (NRC 2022)

Figure 15: Image of a Horizontal Levee (NRC 2022)

The Oro Loma Sanitary District (OLSD) created a horizontal levee with hopes of providing flood control in the San Francisco (County and Institute 2022) Bay area. The East Bay area suffered from an increased risk of coastal flooding from SRL, therefore the creation of the storm surge barrier was necessary to protect the existing infrastructure in 2015. There are plans to create an additional horizontal levee in 2023 due to the success from the 2015 horizontal levee creation. The 'First Mile Horizontal Levee Project' will be south of a wastewater treatment plant. The project will improve water quality and reduce flooding risk. The proposed project is funded from the Water Quality Improvement Fund from the SF Environmental Protection Agency

(Warner 2015). Accordingly, the 2015 horizontal levee project could be considered a successful example of reducing flood risk and preventing sea level rise.

Aesthetic Preferences

There are beliefs that aesthetics and ecological quality are not related to each other, differing in two different objectives: function and appearance. The public is known to prefer orderly landscapes with manicured vegetation, similar to what the traditional American landscape presents – a large exotic grass lawn and clean borders of blooming vegetation (Nassauer 1995b). Unfortunately, North American landscapes are the preferred landscape appearance, while ecologically rich landscapes are considered unpleasing visually (Thayer 1989; Meyer 2008). However, Gobster suggests linking the two complex themes, aesthetics and ecology, in landscapes to bring human values and ecological goals together for better initiative to reclaim ecologically beneficial landscapes in planning, design, and management (P. H. Gobster et al. 2007). This would challenge the current objections to the importance of restoration projects, as they are often seen as not visually pleasing. This discourse negatively impacts restoration initiatives because community support is essential for funding these projects.

Howett describes the 'new ecological aesthetic' as the foundational descriptor for redefining aesthetics with knowledge of ecological systems and their importance in landscapes (Howett 1987). Nassauer further contributes to this discourse by introducing the 'cues for care' design techniques which primarily communicates how care in a landscape such as neatness, stewardship, and naturalness, directly translates to visual pleasure despite ecological function (Nassauer 1995b). This research summarizes that ecologically rich landscapes with 'orderly frames' are viewed as intentionally cared for which is desired by the public, even without previous knowledge in ecology. This is backed by the idea that attractive landscapes are designed and well maintained for because there is value assigned to the landscape by designers. Therefore, landscape designers, land planners, ecologists, and other landscape professionals must utilize the 'cues for care' in coastal resilience to reduce coastal hazard risk.

Assessing Preferences for Adaptations

There are several studies that have assessed the preferences for adaptations to reduce coastal hazards. Landry et al. assessed the preferences of residents in Chatham, Bryan, and Liberty Counties about green, grey, and hybrid infrastructure adaptations using discrete choice modeling (2022). Furthermore, Dumaine et al. introduced a model to equip practitioners and policymakers to employ choice modeling to assess preferences for adaptation choices (2017). In this study, the adaptation measures that are assessed are 'take no action, living shoreline and house relocation and repair seawall and house relocation' (Dumaine et al. 2017). This framework, that was evaluated on the Connecticut coast, addressed individuals' willingness to pay (Dumaine et al. 2017). The results reveal that the sample population preferred hybrid and green infrastructure adaptations for shoreline adaptation measures (Landry et al. 2022). However, Mallette et al. employed a systematic literature review to understand individuals' preferences for climate change adaptations and determined that hard protection adaptations, such as grey infrastructure adaptations, was most favorable (2021). Within this study, they identified elements such as risk perception, implementation cost, and place attachment that influenced the public's preferences (Mallette et al. 2021). Therefore, I used discrete choice modeling to assess the sample population's preference on adaptations to reduce coastal hazard risk (Champ 2017).

Discrete Choice Modeling

Individuals' preferences can be estimated by discrete choice modeling when presented with a set of attributes containing multiple characteristics. The attributes' characteristics can vary in value to allow for a range of results rather than a single result (Champ 2017). With the wide range of variables, discrete choice modeling is successful in assessing preferences in behavioral settings like aesthetic preferences. Assessing aesthetic preferences through images, rather worded questions, can be difficult, however, choice experiments (CE) allow for preference-based valuation due to its experimental design. CE presents a simple format that is understandable and realistic for respondents, which consequently returns precise results. In addition, advancements in the statistical efficacy in CE allow for smaller sample sizes, which is like this study with a population of 200 (Champ 2017).

While attribute-based stated choice experiments are advantageous in behavioral studies focused on preferences, there are multiple tradeoffs that must be addressed. First, hypothetical bias is a concern, because the preferences are contingent on the question format and persuasiveness of multiple-choice options resulting in inaccurate, realistic market choices. Additionally, the multiple attributes and varied characteristics within each attribute result in complex questions which may be difficult for respondents to select, therefore, contributing to the bias of inaccurate response. With the advancements of CE, difficulties in experimental design are common, as well as analyzing the respondents' results (Champ 2017). However, there are many resources available to reduce user error in CE design, so the advantages of experimental question intelligence make this analysis favorable in market valuation, particularly in environmental-based perception studies.

Birol et al. studies the preference heterogeneity in wetland attributes in the Cheimaditida wetland in Greece. Wetlands provide a multitude of ecosystem services for the ecosystem, including flood control, water quality, biodiversity, carbon sequestration, etc. However, poor management practices in the past contributed to the degradation of wetlands. Particularly, Greece lost 63% of their wetlands between the years of 1921-1991. The Cheimaditida wetland remains one of very few freshwater lakes still present in Greece and is considered a priority natural habitat due to its housing several rare, endangered plant species. Birol et al. used choice experiments to study individuals' preferences for the ecological, social, and economic value of wetlands to assist local policymakers and wetland managers to create streamlined policies for sustainable management practices with community input. The specific attributes that studied are biodiversity, open water surface area, research and education, re-training farmers, and costs. The results suggest that respondents prefer wetland management with higher levels of all attributes, particularly biodiversity. Overall, this study helps discern the impacts of different attributes on wetland management and the high heterogeneity in wetland management heterogeneity (Birol, Karousakis, and Koundouri 2006). This research can be an example of using CE successfully in surveys to assign values to environmental characteristics in a behavioral study.

Statistical Analysis

I utilized discrete choice modeling to analyze the aesthetic preferences of the residential community, as it is commonly used in environmental behavioral studies (Champ 2017). I found analyzed the survey results using several techniques. First, cross-tabulation statistics are used to compare different posed question's responses among socio-demographic groups (Qualtrics 2022). I used to find the distributions and statistical fit models of the survey responses (Yale

University 1998; JMP 2023). Craig Landry coded the experimental design using NGENE and analyzed the choice experiment using mixed and conditional logit modeling and marginal rate of substitution, given his expertise in environmental economics (Champ 2017; Train 2009; Landry 2022).

Nonresponse in Surveys

Web-based surveys are helpful for several reasons, particularly in deciphering response rates and breakoff rates (Bosnjak and Tuten 2001). Unit non-response is classified as a 'complete loss' of a survey unit, whereas an item nonresponse refers to 'partially completed and returned' surveys (Bosnjak and Tuten 2001). Breakoff occurs when the respondent starts a questionnaire but chooses to not finish it. Breakoff respondents are different because they do not 'submit' or continue through the end of the survey (Peytchev 2009). There are several reasons for unit nonresponse and breakoff in surveys occur: cognitive ability, sensitive topic, questionnaire length and format, lack of motivation, system initiated timeouts, etc. (Peytchev 2009).

Conclusion

My research focused on the following sections in this literature section: climate change predictions and responses, coastal resilience, gray infrastructure, green infrastructure, hybrid infrastructure, aesthetic preferences, assessing preferences for coastal adaptation, discrete choice modelling, statistical analysis, and nonresponse in surveys. Firstly, the climate change projections and responses research provided insight into coastal hazard risk and vulnerability. The research on coastal resilience also provided information about the current adaptation strategies for reducing coastal hazards. Grey, green, and hybrid infrastructure adaptations were studied for their resilience and costs. I then studied aesthetics and its relation to ecology based on individual preferences. In my research, I examined previous studies that assessed individuals' preferences for coastal adaptations, specifically their methodology. Next, discrete choice modeling was explored to determine how preferences can be assessed. To provide insight into the survey analysis, I studied various methods of statistical analysis. As a last step, I research nonresponse behaviors in survey respondents to gain insight into the reasons for break-offs and non-responses.

CHAPTER 3

METHODS

This study implemented discrete choice analysis to determine preferences of coastal resilient (CR) designs (Landry et al. 2022; Dumaine et al. 2017; Champ 2017). Choice experiments (CE) are used to study individuals' preferences when given several combinations of various attributes, like cost, success rate, etc. (Champ 2017). This study utilizes CE to gauge preferences of CR designs through graphic visualization in a web-based survey (Barroso et al. 2012; Natori and Chenoweth 2008; Karjalainena and TyrvaÈinenb 2002; Jorgensen, Hitchmough, and Calvert 2002; Dillman, Smyth, and Christian 2014). The images utilized for the CE are taken from Google Street view and only manipulated to describe the CR design used for the experiment (Maps 2023). A web-based survey, hosted by SurveyEngine, collected data from the sample group on demographics, general knowledge of coastal resilience, and preferences of CR adaptations (SurveyEngine 2023). The results were analyzed using cross tabulations, counts analysis, fit modeling, and logit modeling (Qualtrics 2022; Yale University 1998; Train 2009).

Study Process

The pilot study was conducted using a survey sent to the Sea Palms West Community Association (SPWCA). An Institutional Review Board (IRB) requires applications for human subject research to be submitted with the necessary documents. It is required by the IRB that the researcher completes CITI certifications. Basic courses, such as Social & Behavioral Research, Ethics, and Internet Surveys, are required for the CITI certification. A recruitment letter, consent form, and survey questionnaire (Appendix B) were submitted to the IRB following the completion of the CITI certification. Upon approval by the IRB, I sent a recruitment email to SPWCA residents. When the respondents completed a survey, the results were updated in the SurveyEngine software, which was analyzed in JMP and by Craig Landry specifically for the discrete choice experiments (Landry 2022; JMP 2023; SurveyEngine 2023). I ran JMP to find the distributions of survey questions to analyze the counts analysis for each question (JMP 2023). Furthermore, I utilized fit models to find relationships between several question's results from a variety questions (JMP 2023). After statistical analysis, I generated tables and graphs for the results in Excel spreadsheets (Microsoft 2023).

Study Area

Sea Palms West Community is a residential, private golf course located on St. Simons Island, Georgia, situated in Glynn County. This course is adjacent to tidal marshes and maritime forests which hosts an ecologically rich environment which the resident's favor. On the greenspace itself, there is overgrown Bermuda grass with unmaintained sand pits and manmade freshwater ponds. Deer, reptiles, amphibians, and a multitude of birds are found roaming the forested areas as well as the adjacent marshes. The Sea Palms West Community Association (SPWCA) currently occupies a defunct 9-hole course, one of which is used as a driving range, that functions as a greenspace for the 340 total residents in the West Community, with one hole leased out for commercial golf use.

Figure 16: Site image of the two freshwater ponds (O'Grady 2018)

Figure 17: Site image of the high marsh and the adjacent defunct golf course (O'Grady 2018)

Figure 18: Site image of hole four adjacent to the tidal marsh (O'Grady 2018)

St. Simons is in the Lower Coastal Plains which is characterized by well drained, sandy soils and minimal topographic changes. This site is characterized by five soil types according to NRCS which include Bohickle Capers association (tidal marsh soil type) and four fine sand soil types (CaB, Ma, Po, and Ru). The topographic range is between zero and 20 ft with most of the site in between four to eight ft elevation (NRCS 2022). St. Simons' climate is characterized as temperate and warm with average high of 76 and low of 60. The average precipitation is around 45 inches per year with a high average humidity of 60-80% (World Weather & Climate Information 2022).

Sample Group

The sample population consisted of the residents in the Sea Palms West Community Association in St. Simons, GA. Sea Palms West Community consists of 340 potential respondents, all living on the western side of the Sea Palms Village. The survey was distributed from Diane Waldron, the director of the HOA, on February 3rd, 2023.

Conceptual Design

First, to choose appropriate design interventions for the site, I employed a vulnerability assessment to determine priority areas to defend against coastal hazards. Figure 2 depicts the sea level rise scenarios and high tide flooding areas (NOAA 2022a). Next, I determined appropriate design alternatives to utilize in the priority areas, based on my research in the adaptation measures. The priority area in the top of the figure depicts the marsh shoreline, which will likely experience one foot of sea level rise in the next 30 years (NOAA 2022a; Sweet et al. 2022). Lastly, I created graphic representation for each of the designs to use in the survey.

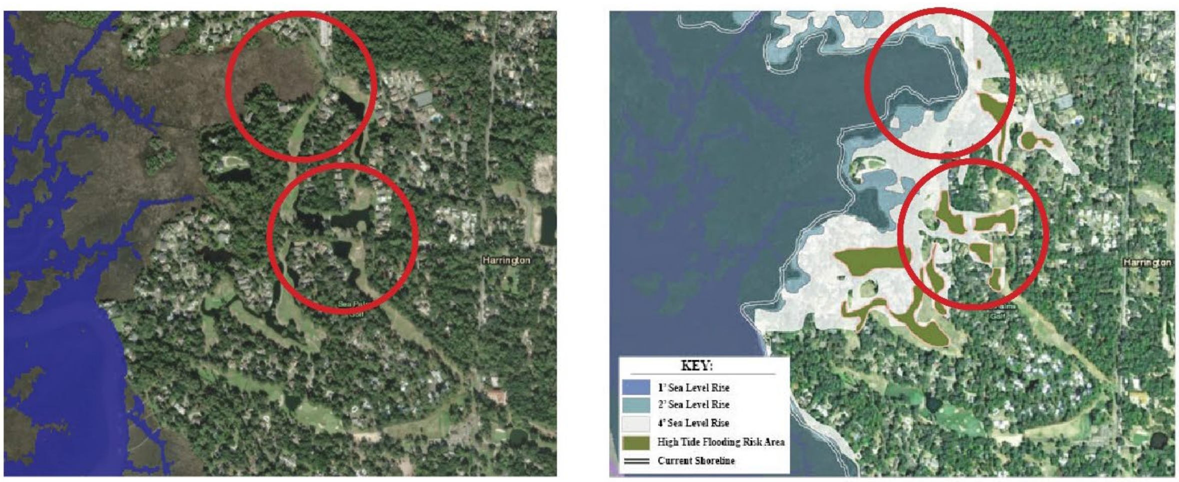


Figure 19: Priority Areas for designing adaptations to reduce coastal hazards.

Graphic Production

Images used for the CE experiment are taken from Google Maps Street view (Maps 2023). The base images for the sites were consistent with similar backgrounds to reduce distraction bias for respondents. Backgrounds were manipulated in some of the original screenshots collected from Google Street View to reduce the 'noise' using Photoshop. Next, the base image was manipulated with Adobe Photoshop v23.3 to graphically represent the design intervention accurately that will be studied. Photoshop tools, such as brush tools and paint bucket, to create the suggestion of vegetation cover and different design interventions such as grass slopes and walking trails (Adobe Suite 2023). The textures used as patterns for some of the layer masks, like grass, concrete, mulch, soil, etc., were found on Sketchup Texture club (Club 2023). The bulkhead and horizontal levee visualizations included a walking path, as this recreation element is attainable for these adaptations (Reguero et al. 2018; NRC 2022). However, the living shoreline visualization did not include the recreation component in order to allow the adaptation area to migrate as sea level rises (NOAA 2022b).

Figure 20: Base image at the marsh enhancement area

Figure 21: Graphic of the bulkhead adaptation at the marsh shoreline enhancement area

Figure 22: Graphic of the living shoreline adaptation at the marsh shoreline enhancement area

Figure 23: Graphic of the horizontal levee adaptation at the marsh shoreline enhancement area

Figure 24: Base image of the pond enhancement area

Figure 25: Graphic of the floating wetland adaptation at the pond enhancement area

Figure 26: Graphic of the littoral shelf adaptation at the pond enhancement area

Questionnaire Design

Using images-based surveys, in contrast to text-based, is beneficial for assessing respondents' visual preferences of landscapes. Image-based surveys are helpful when on-site surveys are not possible or difficult to manage due to proximity to site, visitation regulations, too costly etc. Additionally, image-based surveys are controlled like a laboratory setting, where confounding elements such as wind, insects, extreme weather, etc. won't distract the respondents (Karjalainena and TyrvaÈinenb 2002). Landscapes can be experienced nearly as clearly with photos as they are in real life with similar visual stimuli, however, this is not the case for individuals with visual impairments. Visually impaired individuals cannot use other senses to experience the landscape, therefore this is a limitation when using image-based surveys in research. Despite this challenge, graphic representation is useful in surveys. Photo selection must be carefully chosen to ensure accurate responses, however, photo characteristics such as differences in size, contrast, depth, season, weather, etc. must be scrutinized (Barroso et al. 2012).

Like photo selection, photo manipulation must be carefully applied to ensure response accuracy. Photoshop helps to manipulate images in two ways: reduction of visual distractions not contributing to studies' purpose and manipulation of control variables (Barroso et al. 2012; Natori and Chenoweth 2008). The second manipulation advantage is seen in Jorgensen et. al. research where they manipulated the type of vegetation in images to analyze the interaction between vegetation cover and perceptions of safety (Jorgensen, Hitchmough, and Calvert 2002). Furthermore, manipulating images in image-based surveys can 'isolate' a specific variables or landscape patterns to assign values to the variables (Karjalainena and TyrvaÈinenb 2002; Barroso et al. 2012). Therefore, using image-based questions in surveys is becoming increasingly popular in visual preference studies for its highly specific response accuracy.

The questionnaire was comprised of four sections: previous knowledge of CR and design preferences, perceived risk and assessed risk, discrete choice questions, and socio-demographic questions. The survey questionnaire was developed utilizing the Tailored Design Method from Dillman's book, *Internet, Phone, Mail, and Mixed-mode Surveys : The Tailored Design Method* (Dillman, Smyth, and Christian 2014). Additionally, questions from the Coastal Empire study were utilized to assess the risk perception of climate change and flooding from the respondents (Landry et al. 2022). The first section of the questionnaire included questions examining the sample population's previous knowledge in CR and their willingness to pay for reduction of risk and advantageous characteristics within projects. The following section pertains to coastal hazard risk with questions consisting of the following: the perceived risk on the site, past risk assessment, and predictions of future risk. Next, the sample group responded to image-based questions using discrete choice experiments, designed in NGENE, with several adaptations on two sites and their willingness to pay for these projects (Landry 2022). Lastly, the fourth section pertained to socio-demographic factors.

Section 1: General Knowledge on Coastal Resilience (CR) and Preferences of CR

This section pertains to questions about previous knowledge of coastal resilience and an assessment on the communities' preferences of coastal risk hazards. The questions below are provided for this section:

- Familiarity of Gray, Green, and Grey/Green Hybrid Infrastructure
    - Definition of Infrastructure types
- Components of CR Infrastructure
    - Importance of Various Elements to Reduce Coastal Hazard Risk
    - Willingness to Pay for CR

Section 2: Coastal Hazard Risk Assessment

The survey contained questions pertaining to coastal hazard risk in various categories: perceived risk, past risk, and predicted risk in 25 years. The questions included the following:

- Perceived Risk of Sea Level Rise (SLR)
    - Consequences of SLR
    - Environmental Issues Opinion

    - Storm Flood Risk
- Assessment of Risk on Site
    - Experience of Flooding
    - Assessed Cost of Flood Damage

Section 3: Discrete Choice Questions

The aesthetic preference questions were constructed using a discrete choice experiment (Champ 2017). Discrete choice experiments can assess respondents' preferences for coastal resilience adaptations given several attributes (Champ 2017). The choice experiment asked respondents four image-based questions with three to five of varied attributes. For example, a respondent will be given adaptation graphics to choose from, with each containing a different scenario of varied levels of attributes. Overall, each of the scenarios are given to respondents to overall assess which adaptation is most favorable. The choice experiment will contain two choice sets, each set for the priority areas, to assess the most preferable adaptation scenarios.

There are two choice sets that are specific to two priority areas on the site: pond enhancement and marsh shoreline enhancement. Within the marsh shoreline enhancement choice set, the four alternatives in this choice set that will be compared are living shoreline, bulkhead, horizontal levee, and status quo. For the pond enhancement area, the three alternatives that will be analyzed are floating wetlands, littoral shelves, and status quo. Within each of these scenarios, there are several attributes that will be compared to differentiate which adaptation is preferable for the residential community: HOA additional monthly fee, fish and wildlife habitat quality, water quality, storm flood risk, and high-tide flooding. The pond priority area does not include storm flood risk and high tide flooding days in the set because the adaptations do not change the levels of these specific attributes.

SPCWA Additional Monthly Fee - Cost

The attributes that will be varied for the choice sets are cost (additional HOA monthly fee), storm flood risk, high tide nuisance flooding, wildlife habitat, and water quality. For the costs, it is a willingness to pay question for a monthly fee in addition to the communities' HOA fees. All the adaptations, apart from the status quo, for both areas use four cost options: $50, $150, $300, and $500. These monthly HOA fees are dependent on the probable implementation cost of the adaptations. The period the additional HOA fee is needed is dependent on each adaptation. The status quo cost option is $0 as the assumption is that no changes or maintenance will occur to the area.

Table 1: Discrete choice set one for the marsh shoreline enhancement area, which features the attributes, Storm Flood Risk, High-tide Flood Risk, Fish and Wildlife Habitat, Water Quality, and HOA fee, and their respective levels for the three adaptations, Horizontal Levee, Living Shoreline, and Bulkhead, and existing condition.

Choice Set- Shoreline Enhancement

	Horizontal Levee	Living Shoreline	Bulkhead	Status Quo
Storm flood risk	20%, 40%, 60%	20%, 40%, 60%	40%, 60%, 80%	80%
High-tide flood risk	20, 100, 200	20, 100, 200, 300	20,100, 200,	300
Fish and Wildlife Habitat	Poor	Best, Good, Poor	Poor	Poor
Water Quality	Best, Good, Poor	Best, Good, Poor	Good, Poor	Poor
HOA fee (Monthly)	$50, $150, $350, $500	$50, $150, $350, $500	$50, $150, $350, $500	$0

Table 2: Discrete choice set two for the pond enhancement area, which features the attributes, Fish and Wildlife Habitat, Water Quality, and HOA fee, and their respective levels for the two adaptations, Littoral Shelf and Floating Wetlands, and existing condition.

Choice Set 2 - Pond Enhancement

	Littoral Shelf	Floating Wetlands	Status Quo (No Project)
Fish and Wildlife Habitat	Best, Good	Best, Good	Poor
Water Quality	Best, Good	Best, Good	Poor
HOA fee (Monthly)	\$50, \$150, \$350, \$500	\$50, \$150, \$350, \$500	\$0

Storm Flood Risk

Storm flood risk is defined as the likelihood of severe storm flooding over 30 years. The range varies by the percent chance of a severe storm over 30 years, low storm flood risk being 10% and high storm flood risk being 80%. In the pond area, storm flood risk is not analyzed as none of the adaptations will result in a change in storm flood risk. For the marsh shoreline area, the storm flood risk options are 20%, 40%, 60%, and 80%, however, each adaptation varies depending on its ability to reduce storm flood risk. For the horizontal levee and living shoreline, storm flood risk is reduced due to lower wave attenuation from the enhancement treatment, so 80% storm flood risk is not analyzed (Landry et al. 2022). For the bulkhead, the storm flood risk is only reduced by 40%, 60%, and 80% (Landry et al. 2022). Lastly, the storm flood risk for the status quo is unchanged at 80% chance of severe storm flooding in the next 30 years (Landry et al. 2022). The other flood variable being analyzed is high-tide (nuisance) flooding.

High-tide Flooding

High-tide (nuisance) flooding is defined as the number of days of standing water in low-lying areas, or areas with low elevations (Landry et al. 2022). The unit measured for this level is the number of days. The high-tide flooding days ranges from 20 days to 300 days with the specific options as follows: 20, 100, 200, and 300 days. Like the storm flood risk, the pond areas' adaptations will not change the high tide flooding, therefore, it was not analyzed for this choice set. For the marsh shoreline area, the horizontal levee and bulkhead will not contain the 300-day option, as both adaptations can be high enough in elevation to reduce the high-tide flooding risk (Landry et al. 2022). The living shoreline adaptation will contain all options as this treatment will reduce high-tide flooding risk (Landry et al. 2022). Lastly, the high-tide flooding risk for the status quo is unchanged at 300 days of high-tide flooding days. Each of these adaptations will be evaluated based on wildlife habitat quality.

Wildlife Habitat

Wildlife habitat can be described as the available area where wildlife and fish live that supports their needs. The adaptations are measured by its ability to improve fish and wildlife habitat. Wildlife habitat can be evaluated in several ways; however, this study utilizes a habitat suitability index (HSI) to determine the habitat quality for the Marsh Wren, *Cistothorus palustris* (Johnson 2005; Gutzwiller and Anderson 1987). A habitat suitability index is 'a measure of suitability of habitat for a given species or group of species based on an assessment of habitat attributes' (Southhampton 2023). Habitat suitability indices are often used to predict habitat quality under different management scenarios (Zajac et al. 2023). Therefore, it is useful for this study to predict habitat quality with different design interventions.

Wildlife habitat will be measured in these choice sets as Best, Good, and Poor, with best equaling strong support of healthy ecosystem and poor being a week support of ecosystem. The following table displays the qualitative scores of ‘Best, Good, and Poor’ with their appropriate HSI levels. The HSI for the Marsh Wren is evaluated using four suitability indices: minimum habitat area, canopy cover of emergent vegetation, standing water depth, and canopy cover of woody vegetation. The following equation was used to predict the habitat suitability:

$$HSI = (SIV1 * SIV2 * SIV3)^{(1/3)} * SIV4$$

(Gutzwiller and Anderson 1987). The Marsh Wren are often seen in freshwater wetlands, nesting in Cattails, sedges, and bulrushes. Additionally, they nest in brackish marsh wetlands, typically in cordgrasses (Kroodsma and Verner 2013). Therefore, this species is suitable to use for habitat quality for the freshwater pond enhancement area as well as the shoreline enhancement area.

Table 3: Marsh Wren habitat suitability index (HSI) to quantify habitat quality on the site

Marsh Wren Habitat Suitability Index (HSI)

	Index Value
Best	.75-1.0
Good	.25-.74
Poor	0-.24

Table 4: Preferred habitat qualities for the Marsh Wren

Preferred Habitat Qualities

Minimum Habitat Area	>.4 hect (43055.6 sqft)
CC for Emergent Veg	>57% emergent
Water Depth	>15 centimeters
CC for Woody Veg	<30%

Within the pond enhancement choice set, the littoral shelf and floating wetlands only use the ‘best’ and ‘good’ choices as both treatments will increase wildlife habitat. The status quo treatment only uses the ‘poor’ choice because the wildlife and fish habitat in its existing condition is poor. The marsh shoreline choice set used all the options except for the bulkhead and status quo. Like the pond enhancement, the status quo treatment uses the ‘poor’ choice. The bulkhead adaptation utilizes ‘good’ and ‘poor’ options, as this adaptation will not increase the wildlife habitat quality to the ‘best’ category. Like habitat, water quality was analyzed to evaluate more ecosystem health attributes.

Water Quality

Water quality can be defined as “the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use” (Daniels et al.). The choice sets are measured by increasing water quality. Water quality will be measured by testing the dissolved oxygen, pH, temperature, and nutrient levels such as Nitrogen and Phosphorus (GAEPD 2020). For this survey, water quality will be characterized by a qualitative score as ‘best’, ‘good’, and ‘poor,’ which will be compared to current water quality scores found on GOMAS (GOMAS 2021). The site is located near the Mackay River, which is part of the Altamaha River system. This river system is classified as recreational use, which contains specific measures of each of the water quality indices (State of Georgia 2022). The following table reports the averages of dissolved oxygen, pH, and water temperature of the Mackay River (GOMAS 2021). For the survey, the water quality uses the same choices for all the adaptations, including the exceptions.

Table 5: Water quality assessment using dissolved oxygen, pH, and water temperature.

Altahama River - Mackay River - St. Simons Sound - Recreation Use:			
	Dissolved Oxygen	**pH**	**Water Temp (F)**
Best	5-6	6-8.5	70-90
Good	4-5	8.5-10 ; 4.0-6	>90 ; >32
Poor	3-4	>10.0 ; <4.0	>90 ; >33

Section 4: Socio-demographic questions

To find correlations between socio-demographic groups and visual preferences, the questionnaire contained questions collection information about the following categories:

- Age
- Gender
- Education
- Employment Status
- Household Income
- Marital Status
- Ethnicity
- Race
- Household Occupancy
- Coastal Residency

The categories above provide information about user groups and their aesthetic preferences to understand differences in certain socio-demographic groups' perceptions.

Analysis

The study utilized cross tabulations to gather information about differences and relationships among the attributes and socio-demographic subgroups. Cross tabulations, also known as contingency table analysis, are helpful for comparing results of one or multiple variables within mutually exclusive groups. Mutually exclusive groups can comprise of different characteristics or socio-demographic groups such as age, race, ethnicity, income level, zip code, etc. (Qualtrics 2022). Overall, this statistical analysis provides responses with reduced error.

I used counts analysis, logit modeling, and cross tabulations to evaluate the survey results. Craig Landry used conditional logit modeling and mixed logit modeling in the software STATA to analyze the discrete choice experiments (STATA 2023; Train 2009; Landry 2022). The logit modeling analysis determined the utility values for the designs and attributes, as well as calculate the willingness to pay estimates (Train 2009). I ran JMP to conduct a counts analysis through the distribution feature, which determined the percentages for the multiple-choice survey questions (de Vaus 2013; JMP 2023). I ran JMP to create fit models to determine the relationship between the respondents' willingness to pay and their risk expectations, flood assessments, and income (Yale University 1998; JMP 2023).

CHAPTER 4

RESULTS

The results revealed that the survey population preferred living shorelines as a design adaptation for the shoreline enhancement design (n=267, four questions). Furthermore, the preferred pond enhancement adaptation is the littoral shelf (n=246, four questions). I distributed the online survey on February 3rd, 2023, to the 340 residents in Sea Palms West Community Association (SPWCA) through HOA listserv email. Subsequent email reminders were sent out on February 13, February 14, February 21, and February 24. There was total 195 respondents, who I will refer to as the sample population. Out of the 195 respondents, 30 respondents could not open the survey due to error (over quota). Therefore, there were 163 respondents who opened and viewed the survey, and among those individuals, 57 completed the full survey (n=57).

Results

General Knowledge on Coastal Resilience (CR) and Preferences of CR

In this section, I surveyed the respondents' previous knowledge of green, grey, and hybrid infrastructure. 58% of the sample group responded to having heard of the term '*green infrastructure'* before, while 39% had never heard about the term and 2% did not know (n=98). 64% of respondents answered with never hearing the term 'gray infrastructure' before, and 35% had heard about the term (n=98). Lastly, most respondents (73%) responded to never hearing the term 'green/grey hybrid infrastructure,' with 19% hearing the term, and 7% not knowing (n=98).

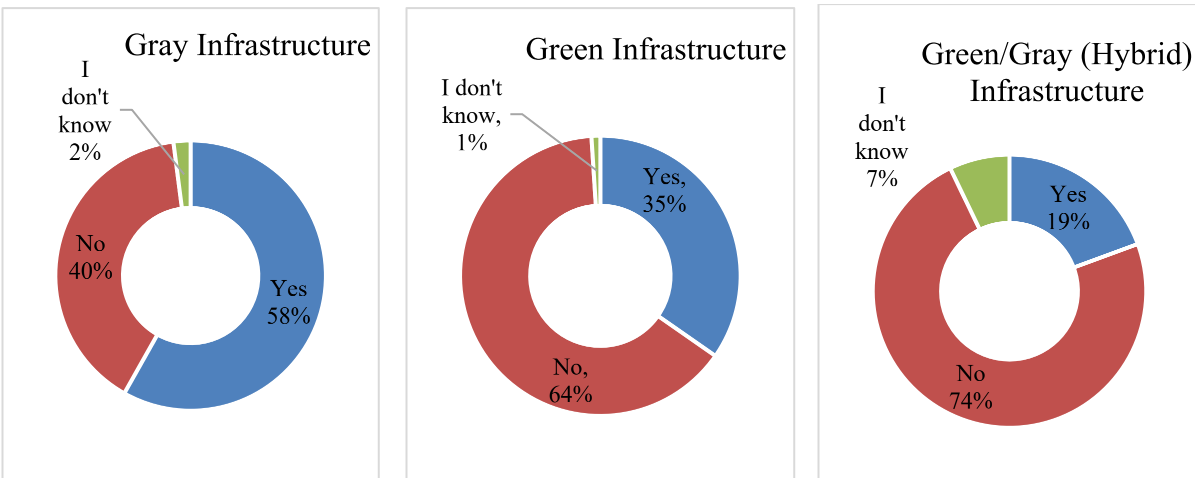


Figure 27: Donut Chart for Previous Knowledge of 'Green | Gray | Green/Gray Hybrid Infrastructure

Table 6: Likert Scale Responses of Importance of Design Invention Features

In your opinion, how important are these features in designing shoreline protection projects to reduce coastal hazard risk?

	Reducing Storm Flood Risk	Reducing High-tide (nuisance) flooding	Providing shoreline fish & wildlife habitat	Costs to my household	Providing water quality
Very Important	78%	76%	71%	82%	61%
Somewhat Important	17%	18%	20%	15%	27%
Neutral	4%	5%	9%	3%	12%
Not Important	1%	1%	0%	0%	1%

The sample population responded to a Likert scale question, ranked from very important to not important, for the following features in designing shoreline protection projects to reduce coastal hazard risk: reducing Storm Flood Risk, reducing high-tide flooding, providing shoreline fish & wildlife habitat, costs to my household, and providing water quality. Over 60% of the sample group found all these features to be 'Very Important'. The 'Cost of my household' attribute had the highest percentage of respondents consider it to be Very Important (82%, n=96).

Moreover, 78% of the survey participants regarded ‘Reducing Storm Flood Risk’ attribute as very important (n=95), while 69% considered ‘Reducing high-tide flooding as very important (n=91). 76% (n=94) considered ‘Providing shoreline fish & wildlife habitat’ as very important in designing shoreline protection projects, followed by 61% of the respondents finding ‘Providing water quality’ very important (n=96). Less than 15% of sample group find all features ‘Neutral’ or ‘Not Important’ as design considerations.

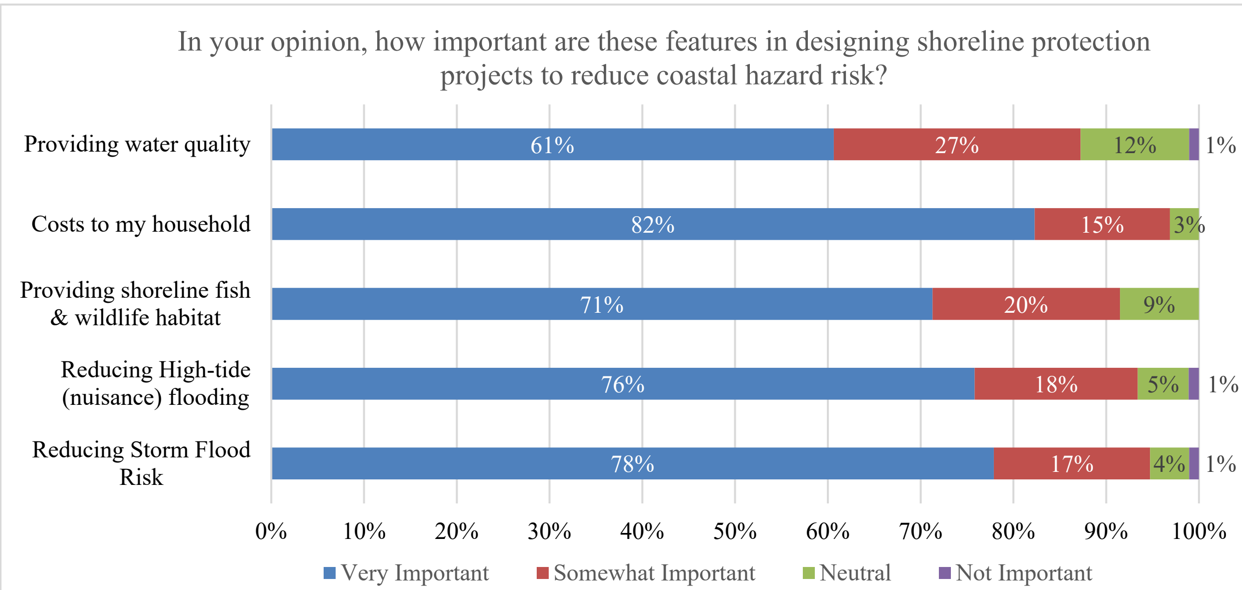


Figure 28: Likert Scale Response Graph of Importance of Design Invention Features

The results reveal that 39% of the population would not contribute any money for coastal resilient adaptations, followed by 37% for $50, 20% for $100, and 3% for $250 or more (n=131). I conducted a linear regression analysis between the willingness to pay for design interventions and household income in the last 12 months to understand their relationship. There was a significant difference between income levels and their willingness to pay (p=0.0431, n=44). Individuals earning $100,000 or more are more likely to pay $100 or more on design interventions, while respondents earning less than $100,000 are more likely to pay $50 or less on design interventions.

I conducted a chi-square test to find the relationship between willingness to pay and respondents' expectations for coastal hazards and adaptation efforts. Respondents who were "Neutral" or "Disagreed" to *flooding problems will get worse* were less likely to pay more for design interventions (p=0.0014, n=83). Furthermore, individuals who "strongly agree" or "somewhat agree" to *roads, bridges, and utilities will need to be fortified against sea level rise and storms* were more willing to pay for design interventions. Lastly, respondents who believe there was a higher likelihood of flooding near their property in the next 25 years were likely to pay more (p=.0001, n=85).

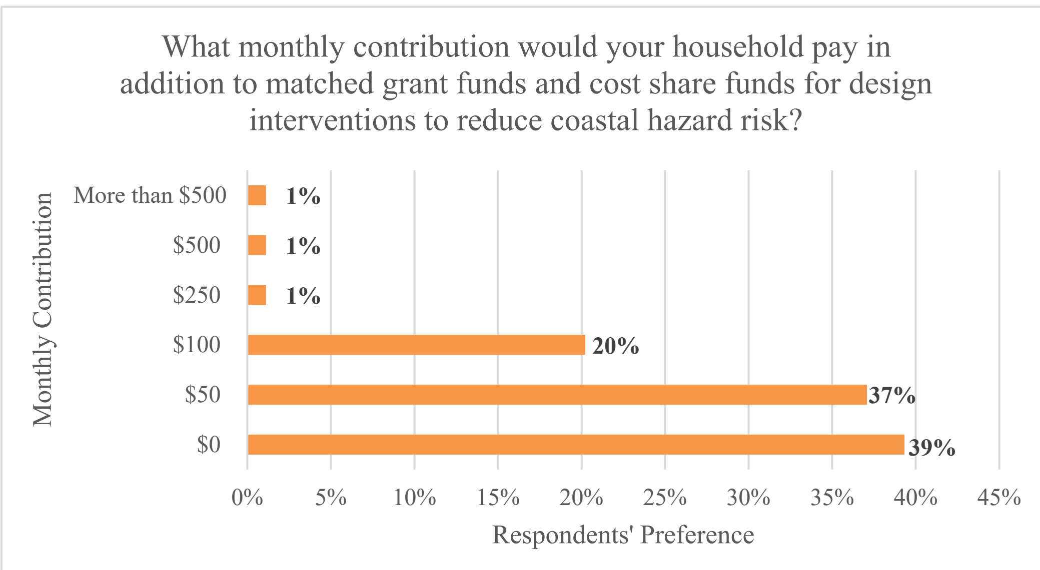


Figure 29: Bar Graph of Willingness to Pay for Design Interventions with Additional Funding like Grants and Cost Share Funds

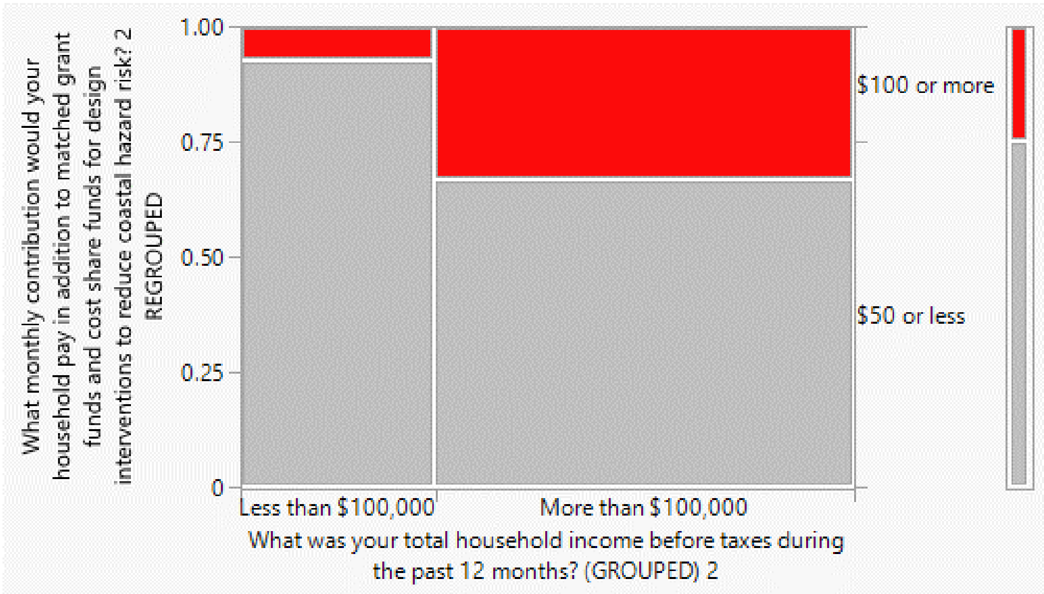


Figure 30: Mosaic Graph of Correlations between Willingness to Pay for Design Interventions and Household Income

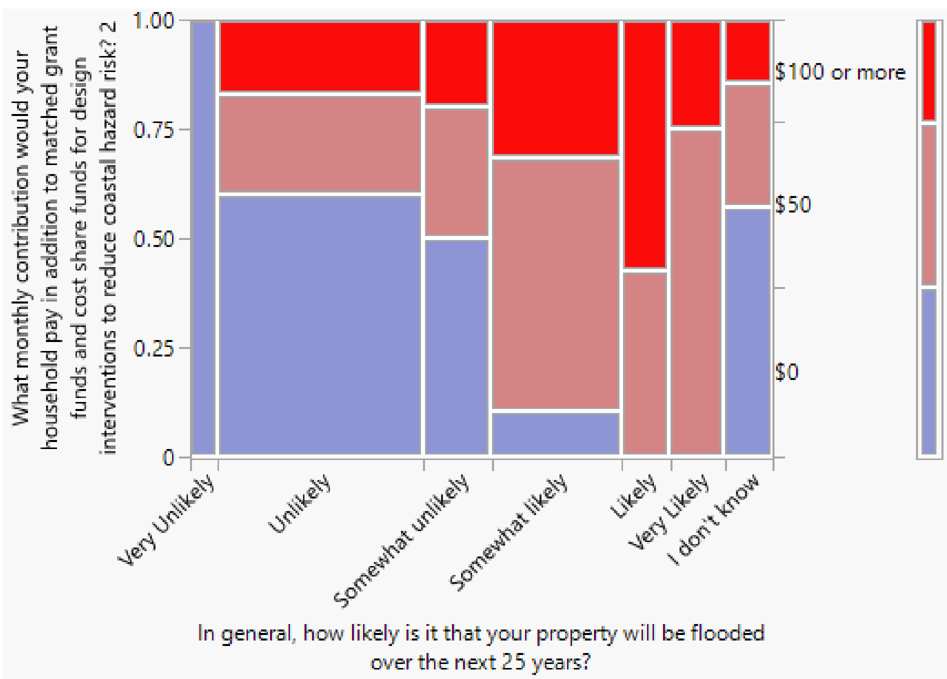
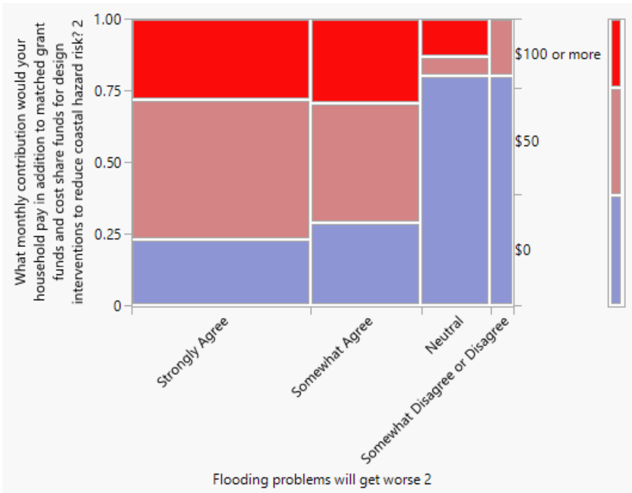


Figure 31: Mosaic Graph of Correlations between Willingness to Pay for Design Interventions and expected likelihood of property flooding in 25 years.



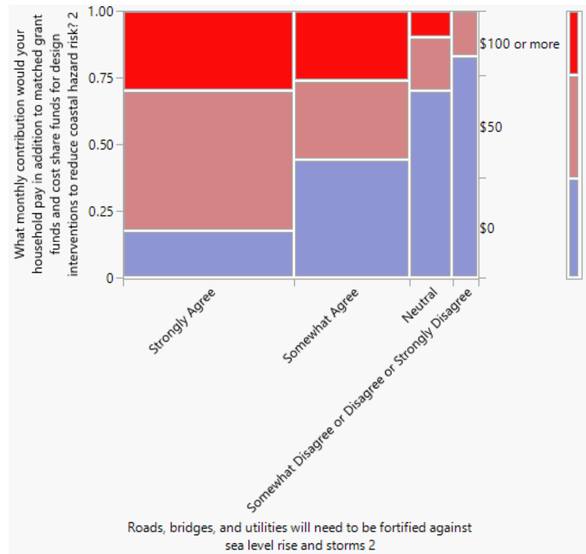


Figure 32: Mosaic Graphs of Correlations between Willingness to Pay for Design Interventions and SLR Expectations (flooding problems will get worse, some buildings will need to be moved or demolished… and roads, bridges, and utilities will need to be fortified…)

Section 3: Coastal Hazard Risk Assessment

Table 7: Likert Scale Responses on Expectations of Sea Level Rise and Consequences

Please indicate how much you agree or disagree with the following statements regarding your expectations for your residence for the next 25 years.

	Sea level will rise	Flooding problems will get worse	Erosion problems will get worse	Coastal storms will get worse	Some buildings will need to be moved or demolished…	Roads, bridges, and utilities will need to be fortified…
Strongly Agree	48%	50%	53%	37%	21%	50%
Somewhat Agree	26%	27%	27%	26%	38%	31%
Neutral	21%	17%	14%	21%	32%	11%
Somewhat Disagree	4%	6%	5%	10%	9%	6%
Strongly Disagree	1%	1%	0%	5%	0%	2%

Most respondents ‘Strongly Agree’ or ‘Agree’ that sea level rise will rise (n=90), flooding problems will get worse (n=90), coastal storms will get worse (n=91), and roads, bridges, and utilities (n=90) will need to be fortified against sea level rise and storms. However, there was a significant proportion who were ‘Neutral’ in response to coastal storms will get worse and some buildings will need to be moved or demolished to avoid flood and erosion risk (n=90). Less than 10% ‘Disagreed’ or ‘Strongly Disagreed’ with these statements, with exception of coastal storms will get worse, with 15% ‘Disagreed’ or ‘Strongly Disagreed’ with the statement.

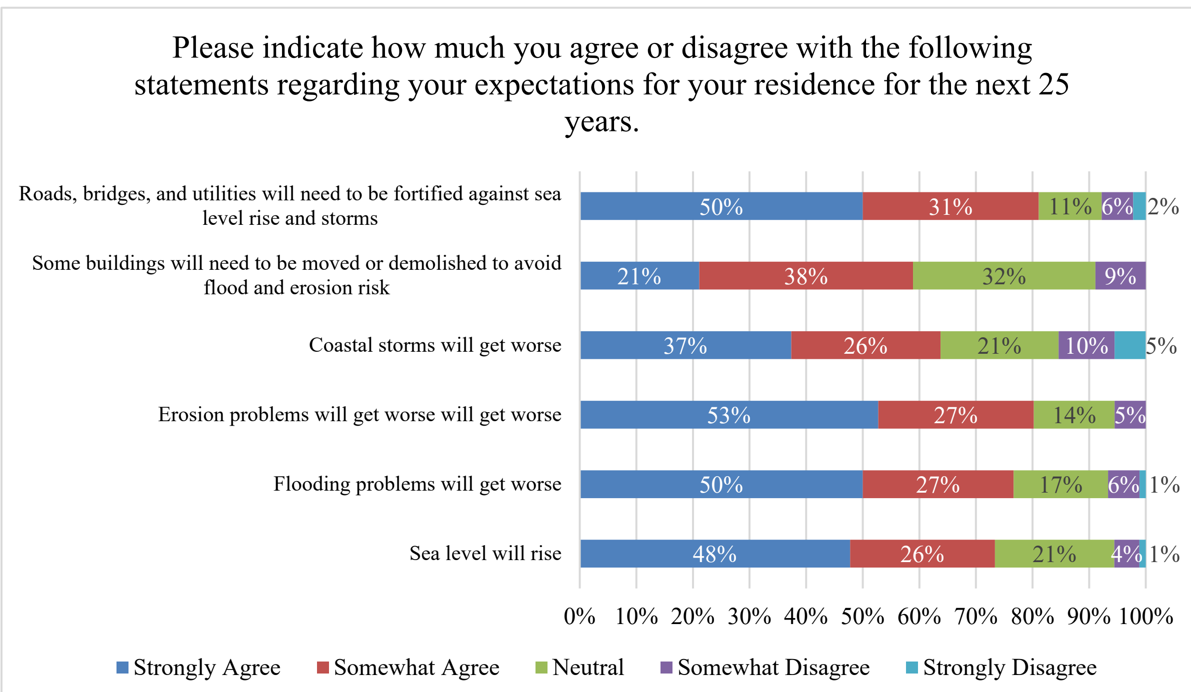


Figure 33: Likert Scale Response Graph of Expectations of Sea Level Rise and Consequences

75% of the survey participants believe there is a chance their home will flood from a weather-related event in the next 12 months (n=91). However, in the next 25 years, 52% believe their property is “very unlikely”, “unlikely”, or “somewhat unlikely” to be flooded (n=92). 21%

agree that it is “somewhat likely” for a flooding event on their property in the next 25 years, while 20% believe it is “likely” or “very likely.” Less than 10% do not know the likelihood. 20% of the sample population expect six or more major hurricanes to occur in the next 50 years, followed by 37% three to five major hurricanes, and 22% one to two major hurricanes (n=89). 21% of the sample group expect ‘maybe one’ or no major hurricanes to occur in the next 25 years.

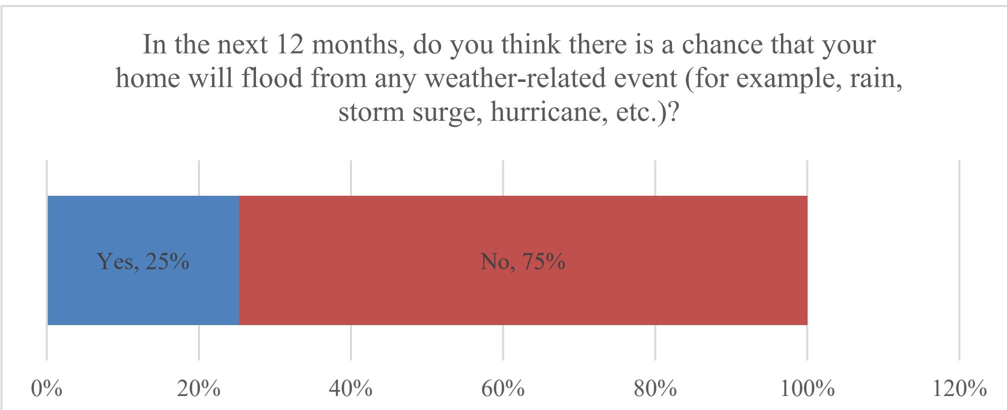


Figure 34: Scaled Bar Graph of Flood Risk Assessment in 12 months

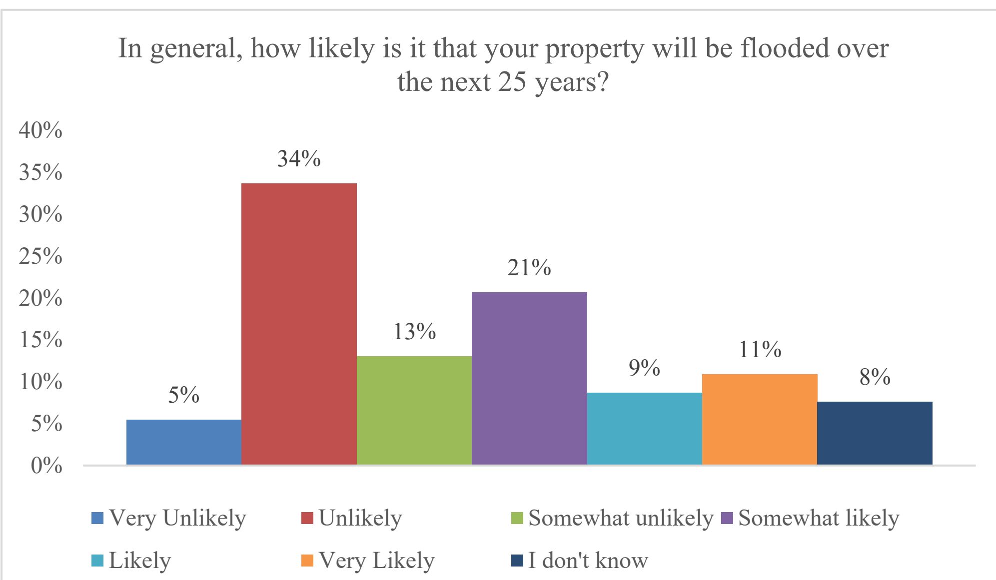


Figure 35: Clustered Column Graph of Flood Risk Assessment in 25 years

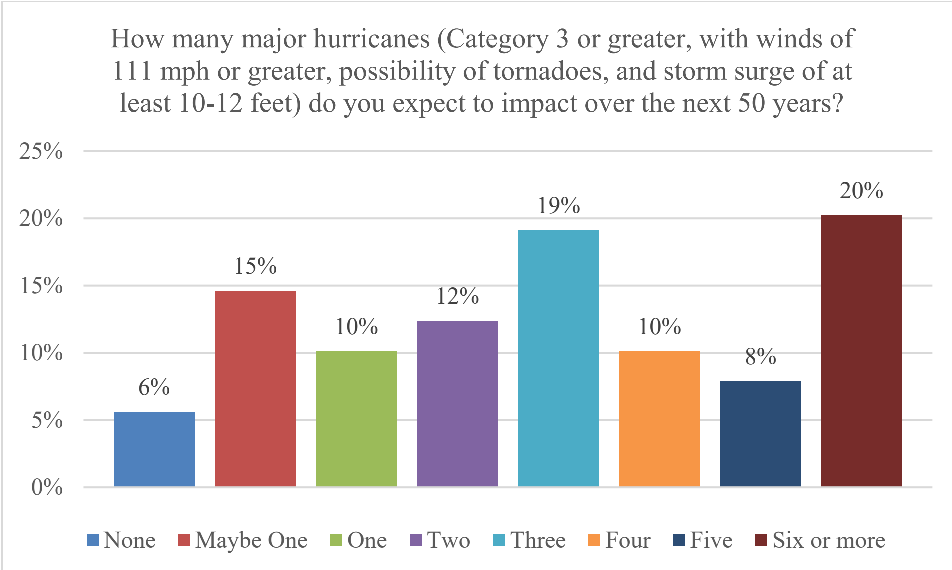


Figure 36: Clustered Column Graph of Perceived Risk of Hurricane Frequency in 50 years

Most of the population perceive that there will be some level of property damage to occur from a local Category 3 hurricane (n=90). Specifically, 40% of the survey participants expect "some damage" to their home from a local Category 3 hurricane, followed by 29% expecting moderate damage, and 22% severe damage (n=90). However, 63% of the respondents reported zero flood events that have occurred within 100 feet of their home, with 14% reporting one event. 23% of the sample group have experienced 2 to 10 flood events on their property (n=91). Of the 37% of the respondents who reported a flood event on their property, 90% did not experience flood damage to their home (n=90).

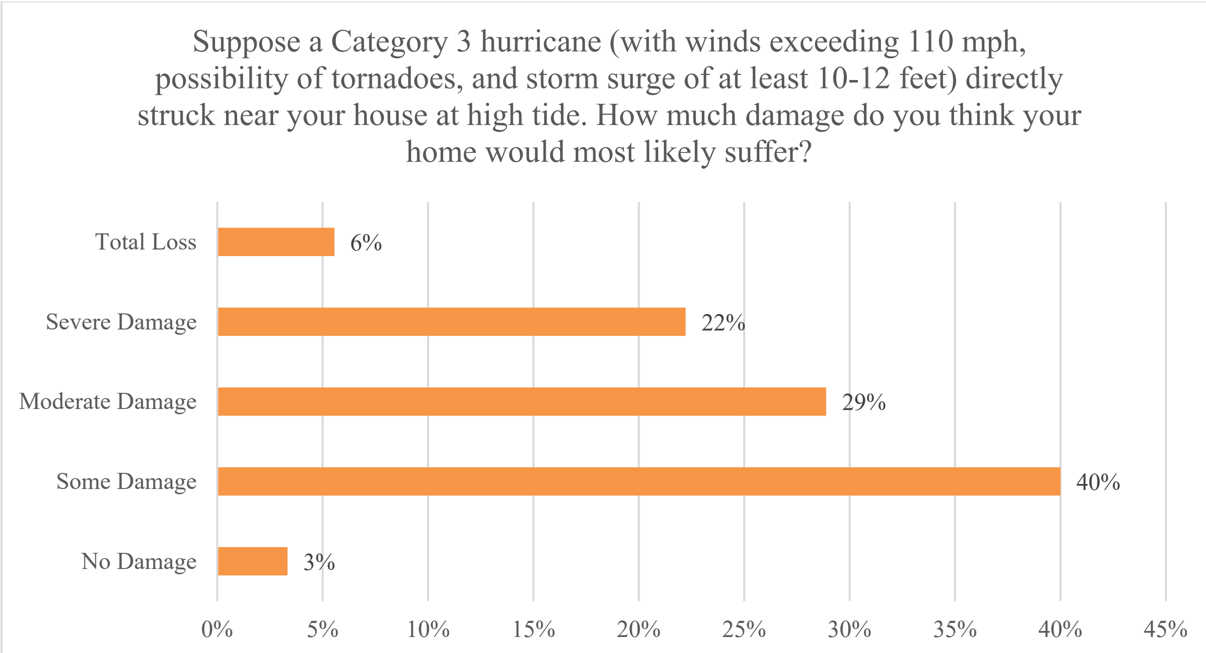


Figure 37: Column Chart for Expected Property Damage from Flood Events

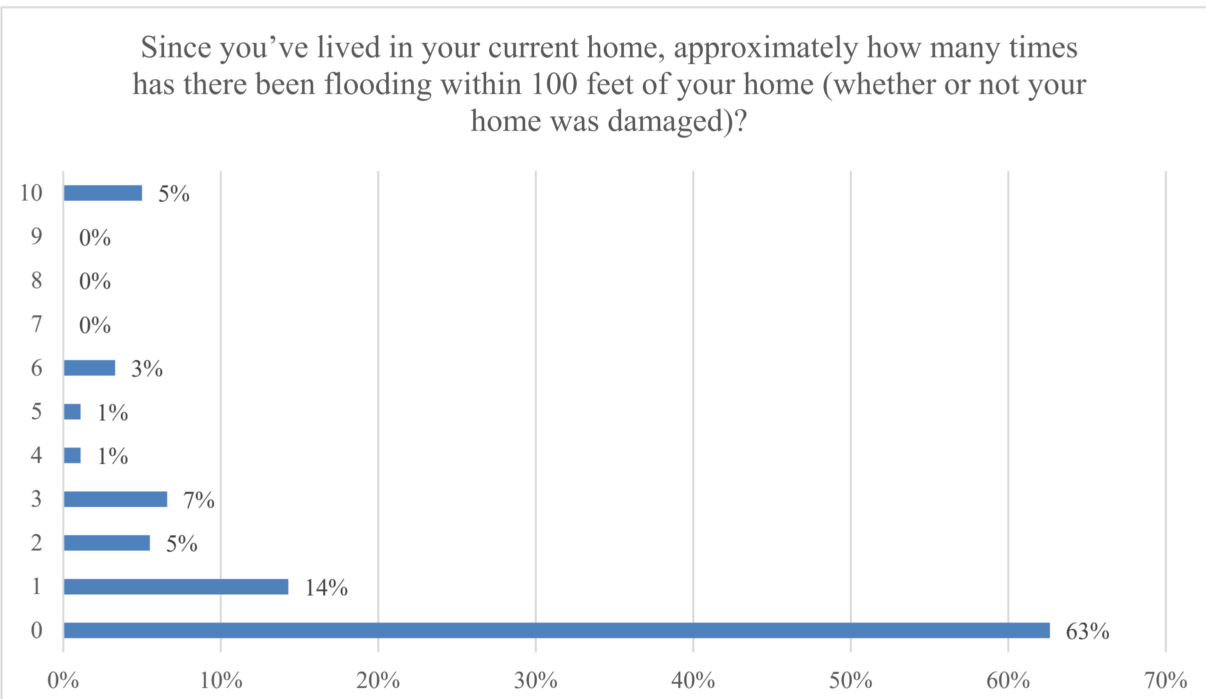


Figure 38: Column Chart for the Flood-Related Property Damage Assessment

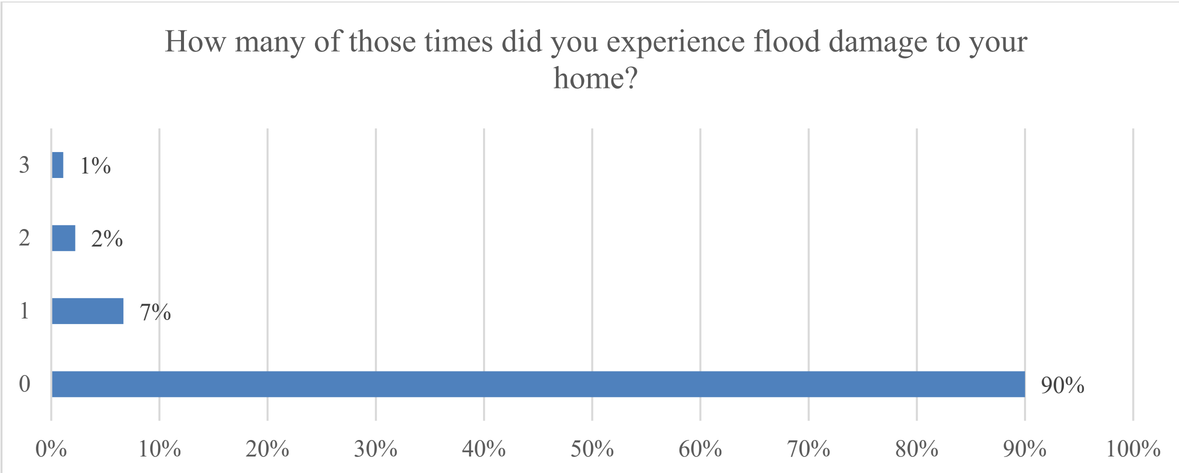


Figure 39: Column Chart for the Frequency of Flood-Related Property Damage Assessment

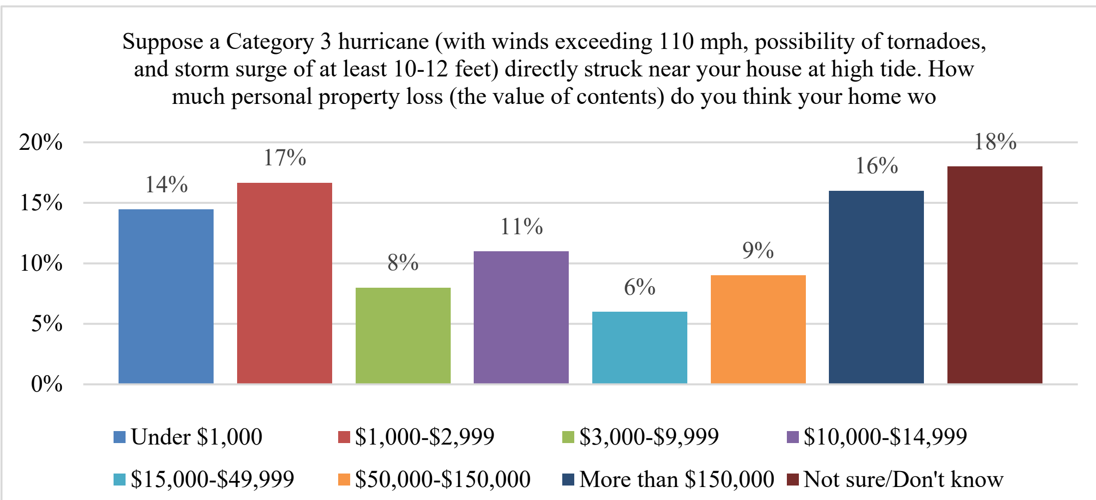


Figure 40: Clustered Column Chart of Personal Property Loss ($) from Flood-Related Events

Section 3: Discrete Choice Experiment

The results reveal the Living Shoreline adaptation is the preferred design intervention among Horizontal Levees, Bulkheads, and status quo (n=267). The respondents were given four design scenarios that surveyed four adaptations which each provided different levels of storm flood risk, nuisance flooding days, HOA fee, wildlife habitat, and water quality. 65% of the survey participants preferred a hybrid adaptation (living shoreline and horizontal levee). 22% of the sample group chose the existing condition compared to the resilient adaptations. 12% of the respondents desired a bulkhead, which is the grey infrastructure alternative.

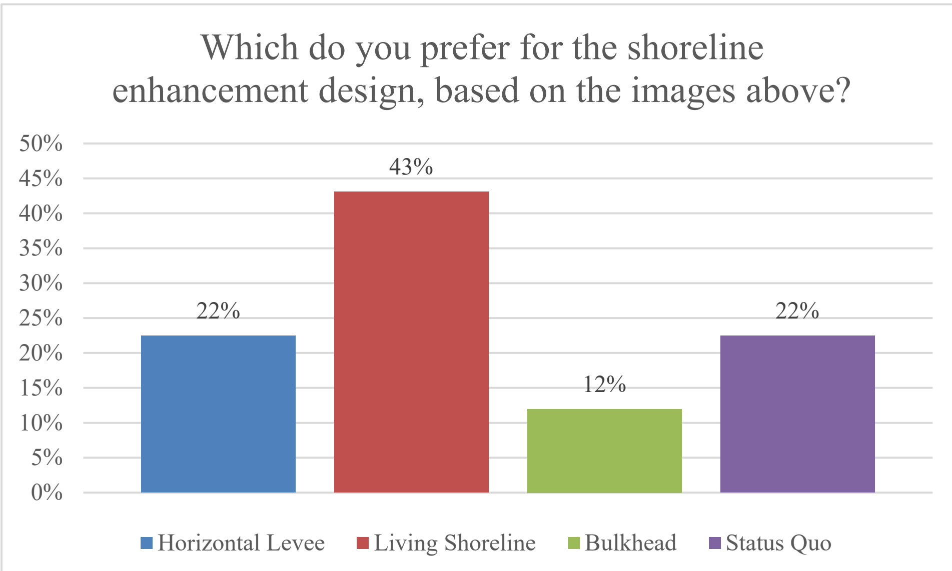


Figure 41: Choice Experiment Design Preference for the Shoreline Enhancement Design

Table 8: Willingness to pay for Shoreline Enhancement Adaptations

Adaptation	Average - WTP
Horizontal Levee	62.92
Living Shoreline	202.90
Bulkhead	25.62

Table 9: Conditional Logit Models for Shoreline Enhancement

	Model (1)		Model (2)	
Choice	Utility	Std. Error	Utility	Std. Error
Storm Flood Risk	-1.5901*	(0.8580)		
Nuisance Flooding Days	-0.0018*	(0.0010)		
Habitat 'Good'	-0.2568	(0.2854)	-0.2665	(0.2856)
Habitat 'Best'	0.3443	(0.2306)	0.3291	(0.2287)
Water Quality 'Good'	0.9402***	(0.2322)	0.9165***	(0.2324)
Water Quality 'Best'	0.9901***	(0.2690)	0.9498***	(0.2688)
HOA Fee	-0.0035***	(0.0006)	-0.0034***	(0.0006)
Horizontal Levee	0.4846	(0.2978)	0.5460*	(0.3062)
Living Shoreline	1.3453***	(0.2991)	1.3704***	(0.3027)
Status Quo	1.3820***	(0.5068)	1.1362**	(0.4465)
ln_sr			-0.6292*	(0.3506)
ln_fd			-0.1725*	(0.0928)
Observations	1068		1068	
p-values	* p<0.10	** p<0.05	*** p<0.01	

Table 8 reveals the results for the willingness to pay for each of the shoreline enhancement designs, excluding status quo. The respondents' most favorable adaptation was the living shoreline, and on average, the respondents are willing to pay $202.90 monthly until design implementation. Furthermore, the sample group are willing to pay the average amount of $62.92 per month for the horizontal levee, followed by $25.62 monthly for bulkheads. The Status Quo adaptation is not included because it is existing condition. The table above displays the results for the conditional logit models from the shoreline enhancement choice experiment (Landry 2022). In Model (1), the 'Status Quo' adaptation has the highest utility (1.382, p<0.01); however, it has the highest standard error (0.507). The 'Living Shoreline' design has a slightly lower utility (1.345, p<0.01) with a lower standard error (relative to 'status quo'). Model (2) reveals that the 'Living Shoreline' design has the highest utility (1.3704, p<0.01), followed by 'Status Quo' (1.1362, p<0.05). 'Horizontal Levee' reported low utility values in both models, with Model (1) not being statistically significant and Model (2) with a high type (1) error in significance (p<0.1). In model (1), storm flood risk and high-tide flooding day risk have negative utility values, indicating that minimizing the attributes is preferred. The 'best' habitat quality utility value was positive, but not significant. The 'good' and 'best' for water quality utility values are positive and statistically significant (p<0.01).

Table 10: Mixed Logit Models for Shoreline Enhancement

	Model (3)		**Model (4)**	
Choice	Utility	Std. Error	Utility	Std. Error
Storm Flood Risk	-1.5083*	(0.9097)		
Nuisance Flooding Days	-0.0024**	(0.0011)		
Habitat 'Good'	-0.1277	(0.4642)	-0.2042	(0.5163)
Habitat 'Best'	0.8067**	(0.3989)	0.7600*	(0.3881)
Water Quality 'Good'	1.2159***	(0.2609)	1.2505***	(0.3080)
Water Quality 'Best'	1.3224***	(0.4009)	1.2835***	(0.4155)
HOA Fee	-0.0050***	(0.0013)	-0.0052***	(0.0015)
Horizontal Levee	0.2578	(0.3927)	0.3139	(0.4310)
Living Shoreline	1.4532***	(0.4981)	1.4501***	(0.5212)
Status Quo	-15.9446***	(3.8690)	-5.9309***	(2.1643)
ln_sr			-0.4968	(0.4090)
ln_fd			-0.2382**	(0.1099)
Habitat 'Good'	0.7931	(0.5286)	1.0736	(0.7646)
Habitat 'Best'	1.1165**	(0.5032)	-1.1903*	(0.6137)
Horizontal Levee	-0.4924	(0.4040)	-0.6598	(0.4541)
Living Shoreline	1.6897***	(0.3615)	1.7139***	(0.3617)
Status Quo	21.6841***	(4.3011)	11.8554***	(2.8191)
Observations	1068		1068	
p-values	* p<0.10	** p<0.05	*** p<0.01	

The following table reports the Mixed Logit Models (3) and (4) for the shoreline enhancement choice experiment (Landry 2022). In both models, ‘Status Quo’ has the highest utility value (p<0.01). The values are negative and statistically significant. The ‘Living Shoreline’ design intervention followed with positive and significant values (p<0.01). The ‘horizontal levee’ is not significant, p>0.1, and reported low utility values with a high standard error (relative to utility). The storm flood risk and high-tide flooding are both negative and significant. The ‘best’ habitat coefficient (p<0.05) and ‘good’ and ‘best’ water quality coefficients (p<0.01) are positive and statistically significant.

Table 11: Willingness to Pay for Conditional Logit Model (1) for Shoreline Enhancement

WTP_storm_~k: -1*(_b[storm_risk]/(_b[hoa_fee]))

Choice	Coef.	Std. Error	z	p>|z|	95% C.I.	
Willingness to Pay: Storm Flood Risk	-458.3658	274.113	-1.67	0.094	-995.6174	78.88587

WTP_flood_~s: -1*(_b[flood_days]/(_b[hoa_fee]))

Choice	Coef.	Std. Error	z	p>|z|	95% C.I.	
Willingness to Pay: Nuisance Flooding Days	-0.533173	.2988736	-1.78	0.074	-1.118954	0.0526087

WTP_hab: -1*(_b[best_hab]/_b[hoa_fee])

Choice	Coef.	Std. Error	z	p>|z|	95% C.I.	
Willingness to Pay: Habitat	99.23958	68.73994	1.44	0.149	-35.48823	233.9674

WTP_wq: -1*(_b[best_wq]/_b[hoa_fee])

Choice	Coef.	Std. Error	z	p>|z|	95% C.I.	
Willingness to Pay: Water Quality	285.4083	90.9687	3.14	0.002	107.113	463.7037

The results reveal the willingness to pay estimated margins for each attribute (Table 11). The respondents are willing to pay $458 per month to reduce storm flood risk. The sample group is willing to contribute $0.53 monthly to reduce the high-tide flooding days. Furthermore, the population is willing to pay $99 per month to improve wildlife and fish habitat, however it is not significant. The sample population is willing to contribute $285 monthly to improve water quality. The willingness to pay estimates has high standard errors, therefore the confidence intervals are large. The negative utility value reveals that willingness to pay (WTP) value and the attribute is an inverse relationship, meaning if one value increases, the other will decrease. For example, the negative WTP for storm flood risk describes that individuals are willing to pay for a decrease in storm flood risk.

The survey results reveal that 48% of the sample group preferred the Littoral Shelf adaptation among littoral shelf, floating wetlands, and the existing condition (n=246). The respondents were given four design scenarios with three adaptations which presented varied levels for HOA fees, wildlife habitat, and water quality. 74% of the sample group chose pond enhancement adaptations over the existing condition. 26% of the sample group chose the floating wetland.

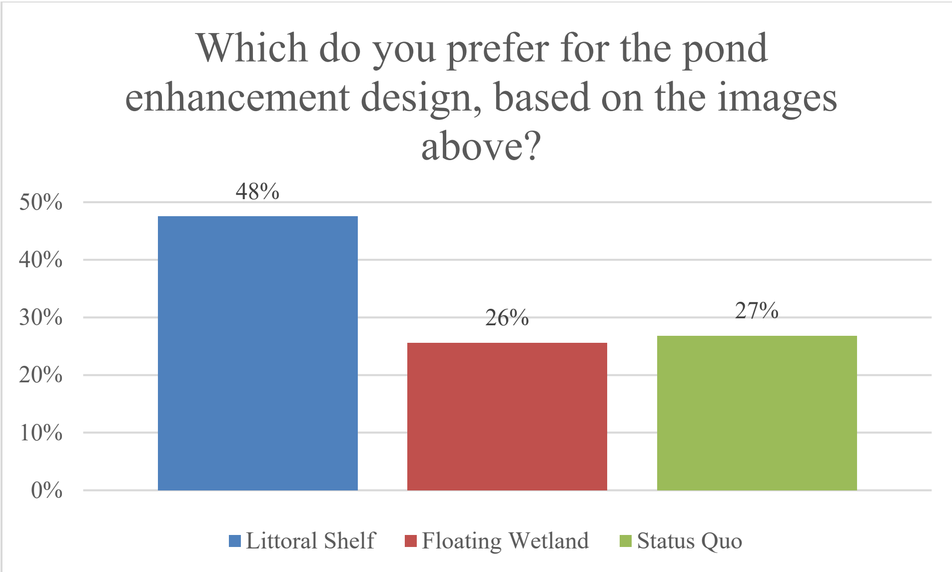


Figure 42: Choice Experiment Design Preference for the Pond Enhancement Design

Section 4: Socio-demographics Questions

The respondents consisted of 33 females (n=58, 57%), 24 males (n=58, 41%), and one 'Prefer not to say' (n=58, < 2%). The age ranged from 33 to 91, with the mean age of 67.5 (n=53). The sample population comprised of mostly White race with 98%, and 'Other' at 2% (n=53). All the respondents do not have Spanish, Hispanic, or Latino origin (n=54). The majority of the sample group is married (84%), followed by Widowed at 9%, Divorced/Separated 5%, and never been married at 2% (n=56).

Most of the sample group are college educated and above, with 40% of the population having a bachelor's degree and 41% with a Graduate or Professional Degree (n=58). 11% of the population received some college, an associate degree, or technical degree (n=58). Most of the population's employment status is Retired at 76%, followed by Working full-time at 12%, Working part-time at 7%, and stay-at-home parent at 5% (n=58). Other than 17% of respondents earning a total household income below $74,999, all other had higher incomes than $75,000 with 15% $75,000 - $99,999, 24% $100,000 - $149,999, and 43% $150,000 or more (n=46).

Table 12: Survey Demographic Distribution

Gender	*% of Total*
Male	41.38%
Female	56.90%
Prefer not to say	1.72%

Age	*% of Total*
66 years or younger	42%
67 years or older	58%

Education	*% of Total*
Some college, but no degree	9%
Associates or technical degree	10%
Bachelor's degree	40%
Graduate or professional degree	41%

Employment	*% of Total*
Working full-time	12%
Working part-time	7%
A homemaker or stay-at-home parent	5%
Retired	76%

Income	*% of Total*
Less than $25,000	2%
$25,000-$49,999	11%
$50,000-$74,999	4%
$75,000-$99,999	15%
$100,000-$149,999	24%
$150,000 or more	43%

Marital Status	*% of Total*
Married	84%
Widowed	9%
Divorced/Separated	5%
Never been married	2%

Ethnicity	*% of Total*
No Spanish, Hispanic or Latino Origin	100%

Race	*% of Total*
White	98%
Other	2%

U.S. Census Data for Glynn County

Table 13: U.S. Census Data for Glynn County (Census 2022)

Gender	*% of Total*
Male	47%
Female	53%

Age	*% of Total*
18-64	73%
65 years or older	21%

Education	*% of Total*
High school diploma or more	89%
Bachelor's degree or more	30%

Income	*Mean*
Average Income	$36,304

Ethnicity	*% of Total*
Spanish, Hispanic or Latino Origin	7%
No Spanish, Hispanic or Latino Origin	93%

Race	*% of Total*
White	69%
Black or African American	26%
Other	5%

Glynn County is made up of 53% female and 47% male. 73% of Glynn County's population is 18-64 years of age, while 21% is 65 years of age or older. 89% of the population aged 25 and older earned a high school diploma or GED, and 30% earned a bachelor's degree. The average income for Glynn County residents is $36,304. The majority of the population is of White race (69%), followed by Black or African American at 26%, 5% Other. Lastly, 7% of Glynn County individuals have Spanish, Hispanic, or Latino ethnicity.

Timestamp Analysis

Overall, the respondents who fully completed the survey submitted it in 21.5 minutes. The questions that experienced low response rates in comparison to the previous question were pages, 3, 6-9). 30% of respondents opened the survey but chose to exit the survey before submitting (n=195). On page three, 49% of the sample group did not respond to the questions, which indicates survey breakoff or omission to respond. Moreover, on page six, 58% did not respond to the questions and 67% did not respond to page 9.

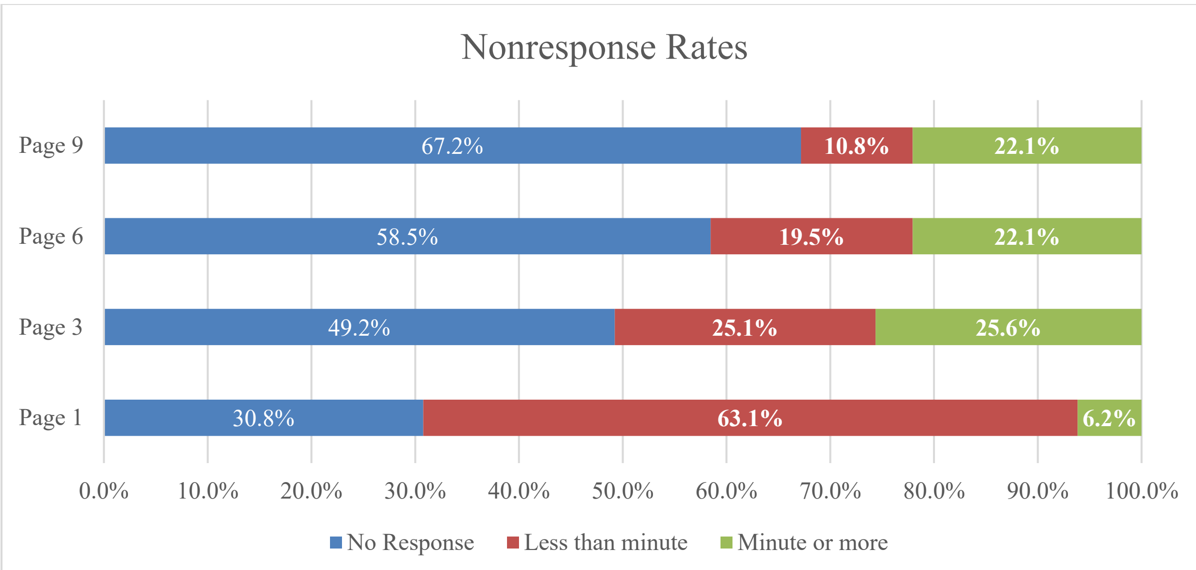


Figure 43: Column Chart of duration time on each page of the survey

CHAPTER 4

DISCUSSION

Results from this study indicate that respondents prefer the living shoreline adaptation, compared to a horizontal levee, bulkhead, or the status quo, for the shoreline enhancement design. Understanding the preferences of shoreline adaptations provides knowledge to increase community input in coastal resilience design. Furthermore, the respondents chose the littoral shelf for the pond enhancement design. Similarly, this information is beneficial in understanding the community's preferences and maximizing community satisfaction in providing stormwater management services in residential areas. For both choice experiments, there were not significant findings for specific demographic group's preferences, because the sample population is relatively homogeneous. Despite this limitation, this information is crucial for designing resilient coastlines and introducing stormwater management in residential communities.

The results reveal that this community prefers a living shoreline adaptation. The survey population revealed they are willing to pay $203 monthly to implement a living shoreline. Additionally, the willingness to pay analysis reveals that they are willing to contribute an average of $458 per month to reduce storm risk, followed by $0.53 to reduce nuisance flooding days, $99 for improved wildlife and fish habitat, and $285 to improve water quality. Living shoreline adaptations are successful in reducing storm flood risk and nuisance flooding, as well as improving water quality and wildlife habitat (Harris 2021; Davis et al. 2015). Therefore, the respondent's preference of living shoreline adaptations is advantageous and fitting, given their desire to reduce storm and nuisance flooding and improve habitat and water quality.

Despite analyzing the choice experiment willingness to pay estimates, there were contradictory results from a willingness to pay question inquired earlier in the survey, which indicated that the majority of respondents are willing to pay $50 or less for coastal resilient design interventions. While these results are contradictory, the choice experiment outlined the benefits that coastal resilient designs provide, which likely influenced the survey participants to increase their willingness to pay.

This study provided insight on the preferences of the SPWCA for coastal resilient adaptations. Figure 46 depicts the priority areas that the living shoreline and littoral shelf adaptation are appropriate on the site. Priority one sites are the areas where the living shoreline and littoral shelf adaptations are the priority when adopting these adaptations. These sites are most vulnerable, with the lens of coastal hazard risk. I created probable construction costs for priority one sites. Furthermore, the priority one sites can be used as demonstrations to implement these adaptations in priority two sites.

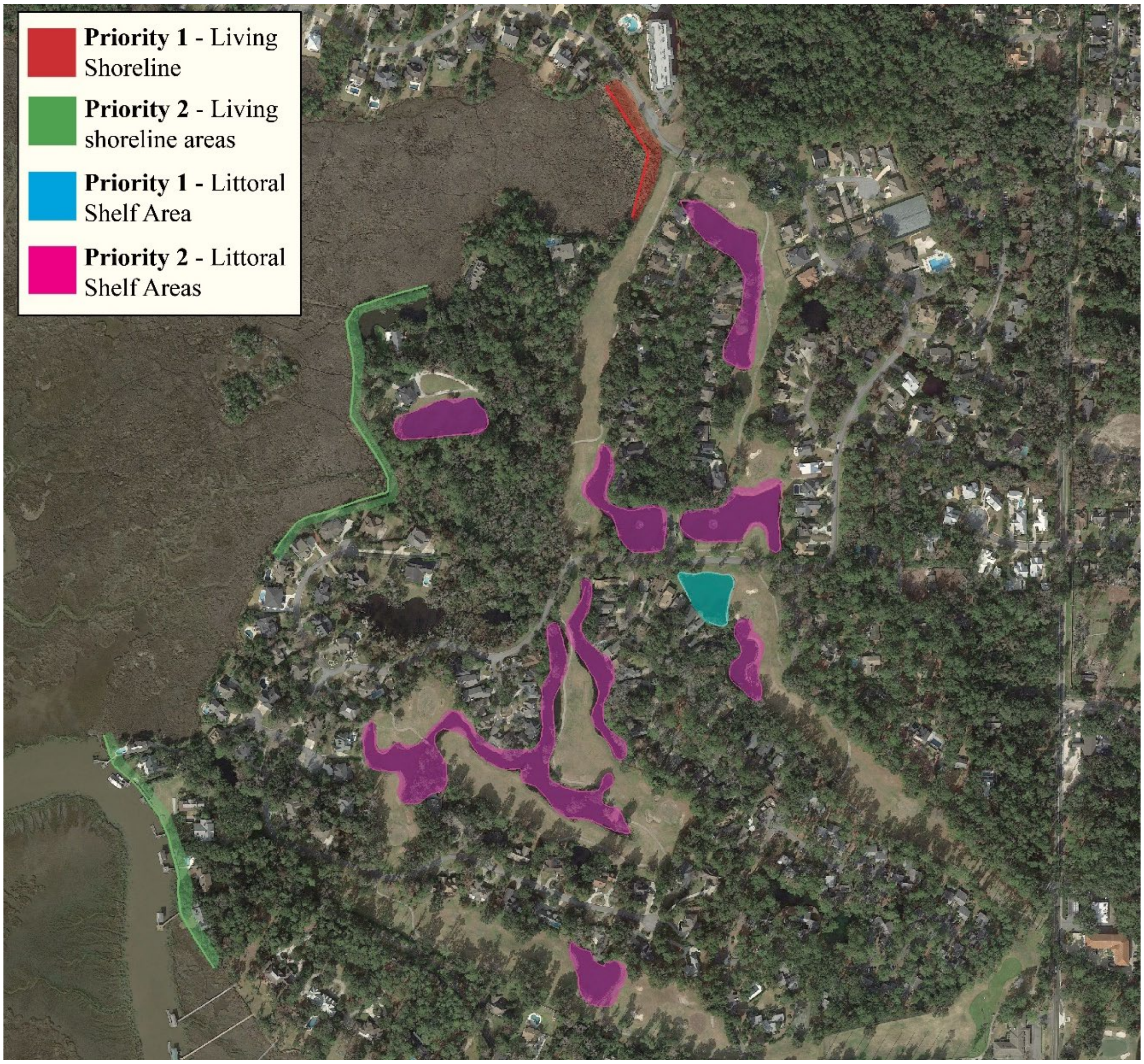


Figure 44: Priority sites for living shoreline and littoral shelf adaptations to reduce coastal hazards.

Most of the residents in Sea Palms West community earned a household income of $100,000 or more in the last calendar year, suggesting that this shoreline design is attainable for the community to implement. On the marsh shoreline, a living shoreline design estimated at 530 linear ft would be an appropriate size for this site. The average implementation costs for living shorelines is approximately $1,000 to $2,000 per linear foot (SAGE 2015). Therefore, this site-specific design would cost approximately $1,060,000, using the highest estimated cost estimates ($2,000/lf). The living shoreline design could be adopted if the 340 residents in SPWCA contributed $200 per month for approximately 16 months (1.3 years). The $200 monthly payment is approximately the cost of the preferred monthly contribution that the sample population is willing to pay ($203). If the residents chose to apply for federal or state grants, the design could be reduced greatly. Another scenario for this living shoreline design could be a $50 monthly contribution for approximately 32 months, alongside grant and cost share funding for 50% of the implementation cost. This scenario considers the understanding that 57% of the population is willing to pay $50 to $100 monthly for coastal resilient design. Overall, I believe this design intervention is attainable for the SPWCA to reduce storm flood risk and nuisance flooding, while providing ecosystem services such as wildlife and fish habitat and water quality.

Figure 45: Living Shoreline Design

Similarly, the respondents chose the littoral shelf for the pond enhancement design. On this site, 540 linear feet of a littoral shelf is appropriate to surround one freshwater pond near low elevations and vulnerable properties. The estimated implementation cost for the littoral shelf design is approximately $61,020. This estimated cost utilizes the highest range for average implementation costs, which is $113 per linear foot (NOAA 2020). This project would cost each resident approximately $180 total to implement the design. This total cost could be broken into monthly HOA fees of $15 monthly over 12 months to implement a littoral shelf in one freshwater pond. Based on the average SPWCA household income, I believe this design opportunity is attainable in providing ecosystem services, such as improved stormwater management, water quality, and habitat quality.

Figure 46: Littoral Shelf Design

Results from this study indicate that most of the survey population is not willing to contribute more than $50 on coastal resilient design adaptations. The findings reveal that their reluctancy to pay is most likely due to their income level and their beliefs that coastal hazard risk is low and will not get worse. This indicates that policy changes and climate information outreach are essential in improving coastal resilient design in residential communities. Policy revisions and amendments must be adopted at a federal, state, and local level.

On a federal scale, there are several ways to improve climate resilience in coastal areas. Environmental and Energy Study Institute (EESI) outlines federal policy recommendations to address climate change with solutions such as increased funding, assistance, and research. EESI discusses the importance of community driven policies, such as increasing interagency coordination and increasing funding and training for local leadership. At its core, local municipalities must be equipped to handle the climate crisis, and federal funding and assistance is essential to ensure local communities are given the knowledge and financial means to achieve this. Next, strategic land planning must be addressed to decrease climate vulnerability in coastal areas. ESSI details that increasing research about nature-based solutions and the long-term cost-benefit analysis of coastal resilient adaptations is crucial in encouraging adoption of coastal resilient designs. Furthermore, federal funding should be prioritized to nature-based or hybrid infrastructure adaptations (Environmental and Energy Study Institute 2020). Hybrid and nature-based infrastructure adaptations are beneficial in reducing coastal hazard risk, as well as provide cost-effective shoreline adaptations (Harris 2021; Davis et al. 2015; Reguero et al. 2018). The federal government should fund and provide aid in conducting climate risk assessments in coastal areas to provide insight on site-specific best management practices. Furthermore, these vulnerability reports can ensure financial resources are allocated equitably to the most vulnerable communities (Environmental and Energy Study Institute 2020).

At a larger scale, federal policymakers must address the possibility of managed retreat (Environmental and Energy Study Institute 2020). Relocation of people due to climate change will become imperative as climate change consequences catalyze in coastal areas, therefore providing funding and assistance to facilitate this movement is vital. Specifically, it is crucial to focus funding and assistance to indigenous communities and low-income areas where managed retreat is difficult due to finances and cultural heritage. Federal buy-out for high risk or previously flood-damaged property can reduce the financial burden of relocation and encourage residents to move to less vulnerable areas. Moreover, federally acquired land can be managed to reduce the climate crisis consequences through appropriate land management, such as protected lands and forests, large-scale coastline renourishment, park planning, and forest and marsh restoration (Environmental and Energy Study Institute 2020).

The Bipartisan Infrastructure Bill, signed in 2021, is providing NOAA $2.96 billion to allocate funding to several coastal resilience initiatives for the next five years. Climate Ready Coasts is the largest initiative that will invest in nature-based infrastructure to build resilient coastlines, through restoration projects, resilient public infrastructure, carbon sequestration initiatives, and removal of marine debris in natural systems. Additionally, $904 million will be used to support research and climate data collection. This initiative will ensure up-to-date climate data and vulnerability assessments to be completed in coastal cities. Lastly, the Fisheries and Protected Resources initiative will receive $592 million to restore essential fisheries habitat to increase economic development and natural resources (Department of Commerce 2022). This bipartisan law is fundamental in creating resilient cities and communities against climate change consequences.

On a local scale, climate adaptative policy can be amended through local planning and regulation amendments, natural system protection, structure and infrastructure projects, and education and awareness programs (FEMA 2013). FEMA outlines specific local planning and regulatory changes such as avoiding hazard areas, increased stormwater regulations, stricter building codes, and increased park and open space planning. First, vulnerability assessments provide information on increased hazardous areas. Local municipalities should deny or reduce development in vulnerable areas to reduce flood disasters. Furthermore, adopting building codes and regulations that withstand future climate conditions and coastal hazards is imperative. Stormwater management will become more necessary to reduce nuisance and storm flooding. On a land management scale, preservation and restoration of coastal natural systems and maximizing open, green space is critical to reduce disastrous flood events. Local governments must adopt land acquisition policies to secure more public land (FEMA 2013).

Local governments in Georgia can adopt Special Purpose Local Option Sales Tax (SPLOST), which is 1% county sales tax to fund local municipality projects (ACCG 2016). Counties in Georgia should implement SPLOST to alleviate the financial burden of coastal resilient adaptation for public utilities and land and flood disaster remediation from the community. The Georgia Census data reveals that the average income in Glynn County is $36,304, which is not adequate to finance coastal resilience in residential communities or private land (U.S. Census 2022). Therefore, allocated funds from SPLOSTs can be used to introduce adaptations such as beach renourishment, marsh restoration, and other nature-based design interventions to reduce flood damage in residential areas. Furthermore, SPLOST funds can be used to incentivize the community to use nature-based solutions on their property through tax deductions and credits, cost share opportunities, and grants. Overall, SPLOSTs can support local communities in adopting coastal resilience. Additionally, local municipalities can apply for loans from Georgia Environmental Finance Authority (GEFA). GEFA supports local governmental groups in distributing loans for water, waste, and energy infrastructure, as well as giving loans for land conservation (GEFA 2023).

The results revealed that a significant number of respondents are ‘neutral’ or ‘disagree’ with the statements surrounding the increased rate of sea level rise, coastal hazard risk, and coastal hazard damage. Local and federal governments must address the lack of education and knowledge surrounding climate change risk in their area. First, federal governments must provide increased funding for local municipalities to give comprehensive climate change information to their constituents. Furthermore, federal policies to allocate adequate funding for climate-related research will be beneficial to increase knowledge around climate risk, adaptations, and mitigation measures (Environmental and Energy Study Institute 2020).

Local municipalities can increase climate change literacy by maximizing education and awareness programs. FEMA equips local governments with several outreach campaigns that are beneficial such as real estate disclosure, public vulnerability maps, adaptation handbooks for homeowners, local workshops, and more (FEMA 2013). In Georgia, the Marine Extension and Georgia Sea Grant is an incredible resource in providing outreach/extension programs and research to local communities (Marine Extension and Georgia Sea Grant 2023). Jill Gambill, the Coastal Resilience Specialist, leads the Coastal Resilience Program, which provides equitable, research-based solutions for communities to implement in their area (Gambill 2023). This agency has several outreach resources such as educational handbooks, resiliency projects, and trainings and workshops (Marine Extension and Georgia Sea Grant 2023).

While there were significant findings in the study, a limitation in this study was the poor response rate, predominately from break-off. While the sample population was considerably small to begin with, therefore the low response rate contributed to a high variation in the reporting. While 59% of the 340 residents chose to open the survey, most of the respondents opened and exited the survey or partially completed the survey (n=329). 29% of the sample group fully completed and submitted the survey (n=57). The results reveal a 30% rate of unit nonresponse on pages 1, which included survey information. One of the reasons for unit nonresponse was the ‘over quota’ survey software error. SurveyEngine has a quota system of 50 people and if there is over 50 respondents to complete the survey, the survey closes to be completed (SurveyEngine 2023). This is a standard setting; therefore, it must be manually changed. Unfortunately, I was not informed about this precondition, therefore, it occurred when my survey reached 50 complete responses. Approximately half of the unit nonresponses are due to this over quota error. I discovered this error quickly and changed to quota to unlimited. I believe lack of motivation and survey topic were the other two contributors to exiting the survey.

Lack of motivation could be due to not having a survey incentive. Studies suggest that a monetary incentive or lottery system prize increases motivation to start or complete a survey (Bosnjak and Tuten 2001; Dillman, Smyth, and Christian 2014). Therefore, in future research on this topic, an incentive could increase the response rate for this survey. Also, I believe the survey topic contributed to the unit nonresponse. Climate change is highly criticized in America (Marlon et al. 2021). Yale conducted a climate opinion study which outlined that the national average of individuals who believe that global warming is occurring is 72% (Marlon et al. 2021). In Glynn County, 69% of the population believe that global warming is happening (Marlon et al. 2021). Therefore, individuals who disagree with this sentiment will be less likely to complete a survey pertaining to this topic.

The findings reveal a high breakoff, which occurred throughout the survey, however there was the highest rate on the first page of questions, page 3, (49%, n=195) and the discrete choice experiment questions, pages six through nine (6=58% ,9=67%). I believe there was a break off on the first page of questions due to testing burden. Peytchev (2009) outlines that breakoff respondents often experience ‘burden’ or ‘perceived burden’, which contributes to their drop out. Moreover, higher question counts can increase the ‘perceived burden’ in a respondent, leading to break off. This is most likely the reason for breakoff on this page. Question content and cognitive ability are other possibilities for the breakoff on the first page of questions.

The results revealed the discrete choice experiment questions (on pages 6-9) experienced high breakoff rates. My hypothesis for this is the difficulty of the question formatting. Several studies outline that a respondent’s age can predict a decreased cognitive ability, due to cognitive aging, which can lead increased breakoff (Peytchev 2009). Discrete choice questions require a higher-level understanding of question structure, as the structure is arranged in a complex design format (Champ 2017). Additionally, the questions require critical thinking and comparison, which increases the question difficulty as well (Champ 2017; Dillman, Smyth, and Christian 2014). Another possibility for the breakoff could be question count, as the response rate increased from page six to nine. It is possible the burden of responding to four separate scenarios was too high, therefore fewer scenarios in a discrete choice question could be investigated in further research studies.

The results indicated a high rate of ‘system-initiated timeout’ by SurveyEngine. On average, surveys were completed in 21.5 minutes. System-initiated timeout occurs when respondents spent longer than 60 minutes, which was the system timeout duration, to complete the survey. One reason for the long completion time compared to the average completion duration could be choosing to complete the survey later and walking away from the screen. Reasons for this could imply low motivation, time conflicts, etc. The second reason that is plausible is cognitive ability. Older individuals might find it burdensome to complete a survey with higher question counts, complex question formatting, etc. Because the results reveal that

58% of the respondents were 67 years of age or older, it is most likely that the question and content difficulties were at fault for the long duration of survey responses.

CHAPTER 6

CONCLUSION

The lack of public support for climate adaptation is a major contributor to the absence of adoption and implementation of these defense measures. To build knowledge of societal perceptions and preferences in coastal adaptation, this study examined the preferences of coastal adaptation in Sea Palms West Community. This information can serve as a demonstration of how to determine communities' preferences locally for practitioners and policymakers. Additionally, this study investigated factors that influence the preferences of this community, including storm flood risk, high tide flooding risk, implementation cost, ecological quality, perception of risk, and water quality. This study provides insights for practitioners about the elements that are advantageous or barriers in adopting coastal adaptation, because they directly influence public engagement in participatory design. This research can equip practitioners, policy makers, and educators with an understanding and addressing the underlying barriers to public support for implementation. Therefore, understanding these elements can give insight to practitioners and policymakers that help build policy as well as adaptation projects that respect the values of the community.

Understanding coastal resilient adaptation preferences of residential communities provides insightful knowledge about coastal resilience. The choice experiment results revealed that the sample population preferred living shorelines for the shoreline enhancement design and littoral shelf adaptation for the pond enhancement design. Participatory design which involves the public and stakeholders helps to increase public's approval and advocacy for climate adaptation. This study provides an case study to practitioners in creating a dialogue and open participation between the public and the designers. This helps to increase community satisfaction and community buy-in to adopt these projects. Additionally, understanding that this community in St. Simons prefers the living shoreline adaptations can influence local policymakers to fund and implement hybrid infrastructure adaptations in their community.

Furthermore, the choice experiment results suggest that the respondents are willing to pay \$468 per month to reduce storm flood risk, followed by \$0.53 to reduce nuisance flood days, \$99 to improve wildlife and fish habitat, and \$285 to improve water quality. While this is insightful, the willingness to pay estimates all have high standard deviations, due to the small population size. Additionally, there are contradictory survey results which reveal that the majority of respondents are not willing to pay more than \$50 for design interventions. Additionally, the majority of respondents believe reducing nuisance flooding and storm flood risk to be 'very important' when designing shoreline protection projects. This information suggests that that while individuals want their landscapes to be more resilient in designing shoreline protection projects, however, they do not want to pay for design interventions.

I believe financial burden is a major barrier in public support of climate adaptation. This ideology suggests that coastal residents believe it is not their responsibility to finance these projects. The community's average household income suggests that contributing financially is not the motivator of their opposition to pay. To address this barrier, federal, state, or local through grants, tax incentives, and costs shares is imperative to increase public support for climate adaptation. In Georgia, a SPLOST could benefit the local community to subsidize these adaptations.

The results reveal that most respondents 'strongly agree' or 'agree' that sea level rise consequences will get worse and public utilities and buildings will need to be moved or fortified to protect against coastal hazards. However, 75% of the survey participants do not believe there is a chance of flooding their property in the next year. Furthermore, 52% of the respondents believe it is 'very unlikely', 'unlikely', or 'somewhat unlikely' that their property can be flooded in the next 25 years. This information suggests that sample population does not have adequate climate data knowledge or do not believe the current climate projections. Therefore, community outreach and education are critical to increase public support of climate adaptations.

Risk perception is a major contributor for the public to support climate adaptations in their communities. These results suggest that some of the sample group believes there is not a risk of coastal hazard to their properties. This belief is likely due to lack of knowledge or misinformation about sea level rise or denial about climate change. Firstly, the lack of knowledge or misinformation can be addressed by comprehensive outreach on climate change. On a federal scale, increasing climate data research can help to direct individuals towards accurate knowledge. Furthermore, federal governments adopting climate mitigation measures and coastal adaptations to reduce coastal hazards can serve as an example that there are likely scenarios of coastal vulnerability. At a local level, public outreach is essential to equip the public with accurate information about the changing climate. Increasing public awareness about the risks can reduce the spread of misinformation about sea level rise.

Furthermore, the politicalization of climate change is likely leading to the lack of risk perception in this community. Marlon et al. (2021) highlights that 69% of Glynn County residents do believe global warming is happening. In fact, 71% of individuals in America believe in global warming (Marlon et al. 2021). Therefore, it is seen that the majority of individuals believe in climate change, however, our politics do not align with this. Drennen and Hardin (2021) revealed that 139 elected officials in Congress do not believe humans are responsible for the acceleration of climate change. These politicians do not represent the views of their constituents. The politicians are likely doing this to reduce the forward movement to green energy. Politicians receive funding and other incentives from oil, gas, and coal companies during their campaign race, therefore opposing climate change eliminates the need to oppose these corporations (Drennen and Hardin 2021). Overall, climate change should not be politicized, because it is leading to misinformation about coastal hazard risk.

It is critical to understand residential community's preferences in coastal resilient design to create more resilient coastlines. The majority of respondents found storm flood risk, nuisance flooding risk, habitat quality, and water quality 'very important' when designing resilient coastlines. These results suggest that residential communities find coastal resilience to be important in their landscapes. Understanding the elements that influence the public's view on coastal adaptations can increase public support. This crucial knowledge can streamline coastal resilience design in residential landscapes to foster implementation and reduce the need for managed retreat. While managed retreat eliminates the need for adaptation and defense against coastal hazards, individuals prefer to stay and adapt to climate change hazards, rather than leave (Buchori et al. 2018). This is likely due to the financial burden for movement and cultural and familial connections to the area. Therefore, understanding community's preferences can inform design decisions while maximizing community satisfaction in the design process.

The results revealed that there was low variation in demographics in the population group. The average individual who responded to the survey is of "White race with no Spanish, Hispanic or Latino origin". Also, most respondents were retired with a college or professional/doctorate degree. Because the community all falls within a similar demographic group, it was not feasible to discern the preferential differences between different socio-demographic groups. Furthermore, the sample group did not represent the average socio-demographic segments in Glynn County, with exception of gender. Therefore, a larger sample size that reflects similar socio-demographic factors to Glynn County would be essential to provide more precise and accurate findings for coastal residential communities at large.

Results from this study provide us knowledge about the preferences among individuals in the Sea Palms West Community Association in St. Simons, GA. St. Simons is a developed barrier island off the coast of Georgia. Jekyll Island, a barrier island directly south of St. Simons, is protected under state law to maintain 65% of the island undeveloped because it is a state-owned park (Gawron 2021). The residential community on Jekyll Island could provide a different perspective on coastal resilience and their preferences of adaptations, given their preference to live on a less developed landscape. Additionally, studying and comparing the coastal hazard risk among both islands would be beneficial in understanding the effect that natural landscapes have on flood risk.

While coastal resilient adaptations are increasingly important to protecting landscapes from coastal hazards, managed retreat is considered the most beneficial in protecting landscapes over time. Coastal squeeze occurs as shorelines continue to retreat and tidal marshlands continue to migrate (Polk et al. 2022). To reduce coastal hazard risk in mainland areas over time, individuals must retreat from coastal areas and revert development to natural areas. Therefore, investigating individuals' likelihood of managed retreat could provide essential knowledge for coastal resilience. Specifically, at what cost, or circumstance will individuals choose to leave their residences to live on the mainland. Additionally, analyzing the reasons that individuals choose to stay in areas, whether that be financially, familial, employment needs, or more.

Furthermore, further research may include more landscape design adaptations, such as marsh restoration, horizontal jetties, and breakwaters. Other research opportunities can study the greatest extent of coastal hazards that individuals would tolerate before retreat or relocation. Similarly, studying individuals’ preferences for property fortification, such as elevating buildings, compared to landscape adaptation and managed retreat. Overall, coastal resilience research is necessary in protecting landscapes against climate change consequences.

Overall, public support is essential for coastal cities to adopt coastal adaptations. Engaging the community through design helps to increase public support and advocacy for coastal adaptation, therefore assessing communities’ preferences on coastal adaptation is beneficial in increasing support. Furthermore, individuals have different experiences, knowledge, or biases that influence their preferences such as risk perception, efficacy of adaptations, financial contributions, etc. Practitioners, policymakers, and educators should address these elements to increase public support by working with the values of their community.

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APPENDICES A

UNIVERSITY OF GEORGIA

Tucker Hall, Room 212
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IRB@uga.edu
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Human Research Protection Program

NOT HUMAN RESEARCH DETERMINATION

January 18, 2023

Dear Krista Campolong:

On 1/18/2023, the Human Subjects Office reviewed the following submission:

Title of Study:	Golf to Green: What is the level of design intervention that people will favor with constraints of climate change
Investigator:	Krista Campolong
Co-Investigator:	Jon Calabria
IRB ID:	PROJECT00006290
Funding:	None

We have determined that the proposed activity is not designed as research involving human subjects as defined by DHHS and FDA regulations. The activity is designed to study/understand aesthetic preferences/attitudes within the Sea Palms West residential community to toward different resiliency design alternatives. The findings will contribute to streamlining of the design process locally. The findings may also be shared widely as an example of how to obtain/use community input in the design process.

University of Georgia (UGA) IRB review and approval is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities are research involving human subjects, please submit a new request to the IRB for a determination.

Sincerely,

Jessica Lasebikan, HRPP Assistant Director
Human Subjects Office, University of Georgia

APPENDICES B

Welcome!

Dear Participant,

My name is Krista Campolong and I am a student in the College of Environment + Design at the University of Georgia under the supervision of Dr. Jon Calabria. I am inviting you to take part in a research study as a part of my master's degree.

I am conducting research about the public's perception of coastal resilient adaptations in residential landscapes, which are designed to reduce coastal hazard risk in residential areas. **Your responses will help us understand how to improve the coastal resilient design in residential landscapes.**

You must be 18 or older to participate in this study. If you agree to take part in this study, you will be asked to complete a survey with four sections. The first section will ask you questions about your previous knowledge of coastal resilience. The second section will ask you questions about coastal hazard risk on the site. The third section will ask you to review photos of coastal resilient adaptations and select the image you prefer visually and based on the adaptation's characteristics such as cost, water quality benefits, wildlife habitat benefits, etc. The fourth and final section will contain questions about yourself. This survey should take about 10-15 minutes.

Participation is voluntary. You can reduce to take part or stop at any time without penalty. You can skip any questions if you do not wish to answer them. Your responses will be kept confidential.

If you have any complaints or questions about your rights as a research volunteer, contact the IRB at 706-542-3199 or by email at IRB@uga.edu
If you have any questions about this research, please feel free to contact me at:

Krista Campolong
Master of Landscape Architecture Candidate
University of Georgia
College of Environment + Design
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Athens, GA 30603 USA
Email: kac92575@uga.edu

If you proceed forward with the survey, it is implied that you have read the information above about the research, your rights as a participant, and give your voluntary consent.

Screening Question:

You must be 18 or older to participate in this study. Are you 18 or older?

1) Yes
2) No

Previous Knowledge:

Suppose that SPWCA is seeking input on programs to install coastal hazard mitigation infrastructure to help control flooding, erosion, and potential negative effects of sea level rise in your community. The Federal government is willing to help with the costs, but some of the money will need to come from citizens of SPWCA.

The coastal hazard mitigation options can be classified with the following definitions:

'Gray' infrastructure – use of concrete, steel, timber structures, etc. to manage water and sediment flow - this option cannot adapt to changing environmental conditions.

'Green' Infrastructure – use of natural features, such as marshes, oyster reefs, living shorelines, vegetated berms, etc. to manage water and sediment flow - this option can adapt to changing environmental conditions.

Hybrid 'Grey/Green' Infrastructure – a mix of hard structures and natural features to manage water and sediment flow - this option has some ability to adapt to changing environmental conditions.

Had you heard of “green” infrastructure before reading the above information?

1) Yes
2) No
3) I don’t know

Had you heard of “gray” infrastructure before reading the above information?

1) Yes
2) No
3) I don’t know

Had you heard of “green/gray” infrastructure before reading the above information?

1) Yes
2) No
3) I don’t know

These shoreline protection projects can provide an array of ecological services, including:

Storm flood risk – the likelihood of severe storm flooding over 30 years. Storm flood risk can range from:

- Low storm flood risk: 10% chance of severe storm flooding over 30 years to
- High storm flood risk: 70% chance of severe storm flooding over 30 years

High-tide (nuisance) flooding – reducing the number of days of standing water in low-lying areas. High-tide flood risk can range from:

- Low nuisance flooding: 10 - 20 days/year of standing water in low-lying areas to
- High nuisance flooding: 100 - 150 days/year of standing water in low-lying areas

Shoreline fish and wildlife habitat – improving fish and wildlife habitat along shorelines

- Best: strong support of healthy ecosystem (high habitat suitability for Marsh Wren)
- Good: limited support of ecosystem (medium habitat suitability for Marsh Wren)
- Poor: weak support of ecosystem (low habitat suitability for Marsh Wren)

Cost to your household - Depending upon your income and household size, this would cost your household somewhere in the range of $10 to $900 per year, for each of 10 years (depending upon the program implemented).

Water Quality - improving the water qualities such as dissolved oxygen, pH, salinity, and nutrients

- Best: high water quality (best range of pH, water temperature, and dissolved oxygen)
- Good: medium water quality (good range pH, water temperature, and dissolved oxygen)
- Poor: low water quality (poor range of pH, water temperature, and dissolved oxygen)

In your opinion, how important are these features in designing shoreline protection projects to reduce coastal hazard risk?

	Doesn't matter at all	Not important	Neutral	Somewhat Important	Very Important
Reducing Storm Flood Risk					
Reducing High-tide (nuisance) flooding					
Providing shoreline fish & wildlife habitat					
Costs to my household					
Providing water quality					

What monthly contribution would your household pay in addition to matched grant funds and cost share funds for design interventions to reduce coastal hazard risk?

1) $0
2) $50
3) $100
4) $175
5) $250
6) $500
7) More than $500

Risk Assessment:

The following questions are intended to help us understand your perception of coastal hazard risk on the site and the actual coastal hazard risk on the site. You will be presented with a series of questions. Please read the question carefully and answer to the best of your ability. The questions will be in several formats including multiple choice, fill in the blank, agree/disagree, and ranking statements on which you prefer the most. All your answers are confidential.

Please indicate how much you agree or disagree with the following statements regarding your expectations for your residence for the next 25 years.

	Strongly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Strongly Disagree
Sea level will rise					
Flooding problems will get worse					
Erosion problems will get worse will get worse					
Coastal storms will get worse					
Some buildings will need to be moved or demolished to avoid flood and erosion risk					
Roads, bridges, and utilities will need to be fortified					

against sea level rise and storms					

In the next 12 months, do you think there is a chance that your home will flood from any weather-related event (for example, rain, storm surge, hurricane, etc.)?

1) Yes
2) No

In general, how likely is it that your property will be flooded over the next 25 years?

1) Very unlikely
2) Unlikely
3) Somewhat unlikely
4) Somewhat likely
5) Likely
6) Very likely
7) I don't know

How many major hurricanes (Category 3 or greater, with winds of 111 mph or greater, possibility of tornadoes, and storm surge of at least 10-12 feet) do you expect to impact over the next 50 years?

1) None
2) Maybe one
3) One
4) Two
5) Three
6) Four
7) Five
8) Six or more

Suppose a Category 3 hurricane (with winds exceeding 110 mph, possibility of tornadoes, and storm surge of at least 10-12 feet) directly struck near your house at high tide. How much damage do you think your home would most likely suffer?

1) No Damage
2) Some Damage

3) Moderate Damage
4) Severe Damage
5) Total Loss

Suppose a Category 3 hurricane (with winds exceeding 110 mph, possibility of tornadoes, and storm surge of at least 10-12 feet) directly struck near your house at high tide. How much personal property loss (the value of contents) do you think your home would most likely suffer?

1) $0
2) $1-$999
3) $1,000-$1,999
4) $2,000-$2,999
5) $3,000-$3,999
6) $4,000-$4,999
7) $5,000-$5,999
8) $6,000-$6,999
9) $7,000-$7,999
10) $8,000-$8,999
11) $9,000-$9,999
12) $10,000-$14,999
13) $15,000-$19,999
14) $20,000-$24,999
15) $25,000-$49,999
16) $50,000-$74,999
17) $75,000-$99,999
18) $100,000-$150,000
19) More than $150,000
20) Not sure/ Don't know

Since you've lived in your current home, approximately how many times has there been flooding within 100 feet of your home (whether or not your home was damaged)?

1) 0
2) 1
3) 2
4) 3
5) 4
6) 5
7) 6
8) 7
9) 8
10) 9

11) 10

How many of those times did you experience flood damage to your home?

1) 0
2) 1
3) 2
4) 3
5) 4
6) 5
7) 6
8) 7
9) 8
10) 9
11) 10

Please indicate the dollar amount for the most recent occasion of flood damage **and** the storm event: ____________

Shoreline Protection Project:

The following questions ask you to evaluate shoreline protection projects, designed to last for 30 years, which could be a proposed project in the Sea Palms West Community.

If no river shoreline protection projects are implemented, Glynn County will witness:

- A 90% chance of severe storm flooding over the next 30 years
- 150-200 days/year of standing water in low-lying areas
- Poor fish & wildlife habitat along riverbanks and in freshwater ponds
- Poor water quality along riverbanks and in freshwater ponds

As you assess these potential shoreline protection projects, please keep in mind that the results of this survey may influence the Sea Palms West Community Associations' decisions on project implementation and HOA fee additions. MODIFY AS NEEDED.

Sometimes when individuals are asked whether they support public projects, they are prone to say "Yes" because they feel like it will not actually affect them, actual projects, or actual payments.

- As you answer the following questions, please assume that your response will have an actual effect on the likelihood that these programs will be implemented and funded.

Do you understand the above scenario and feel confident in offering feedback on your support for conventional gray, hybrid, and green riverbank infrastructure projects?

1) Yes
2) No
3) Not sure

DCE – Shoreline – Scenario 1

In this section, you will be presented with four images of coastal resilient adaptations and you will be asked to indicate your preference for the photos. There will be several characteristics of each of the adaptations, such as cost, wildlife habitat, water quality, etc., which will influence your preference. These photos are actual places taken on the site and manipulated to include the adaptation. Please select your preference for the photo you like best. You will complete this question four individual times, however, the attributes will have different values. Please complete all four scenarios.

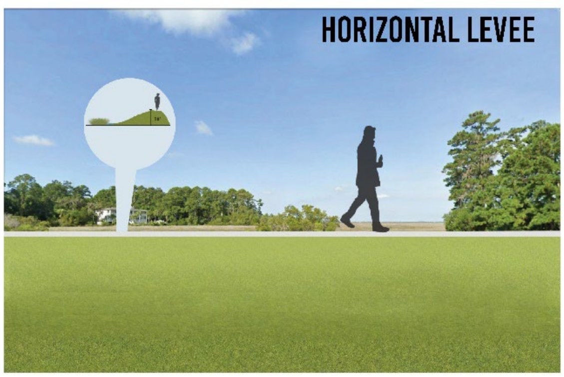
Scenario 1: Shoreline Enhancement

The following definitions are the coastal resilient adaptations that will be represented in the images:

Horizontal Levee: steep-sloped area situated between coastal habitats and existing infrastructure that are typically vegetated. Horizontal Levees reduce coastal erosion and stabilize the shoreline.

Living Shoreline: a shoreline that is comprised of nature-based materials, such as natural vegetation or other living things like oyster beds and mussels. Living shoreline stabilizes the shoreline, reduces erosion, and enhances coastal resilience by providing ecosystem services such as habitat and water quality

Bulkhead: a seawall, typically built from wood or steel, that creates a barrier from the water to land



<u>The following attributes can be defined:</u>

Storm flood risk – the likelihood of severe storm flooding over 30 years. Storm flood risk can range from:

- Low storm flood risk: 20% chance of severe storm flooding over 30 years

  to

- High storm flood risk: 80% chance of severe storm flooding over 30 years

High-tide (nuisance) flooding – reducing the number of days of standing water in low-lying areas. High-tide flood risk can range from:

- Low nuisance flooding: 20 days/year of standing water in low-lying areas

  to

- High nuisance flooding: 300 days/year of standing water in low-lying areas

Fish and Wildlife Habitat – improving fish and wildlife habitat

- Best - strong support of healthy ecosystem (high habitat suitability for Marsh Wren)
- Good - limited support of ecosystem (medium habitat suitability for Marsh Wren)
- Poor - weak support of ecosystem (low habitat suitability for Marsh Wren

Water Quality - improving water characteristics for recreational use

- Best - high water quality index (pH, water temperature, and dissolved oxygen within a high range)
- Good - medium water quality index (pH, water temperature, and dissolved oxygen within a medium range)
- Poor - low water quality index (pH, water temperature, and dissolved oxygen out of range)

Additional HOA fee - additional monthly cost to implement coastal resilient adaptations, until design is paid in full

- $0 *to* $500

	Horizontal Levee	Living Shoreline	Bulkhead	Status Quo
Storm Flood Risk	40%	40%	40%	80%
High-tide Flooding	200 days	20 days	100 days	300 days
Habitat	Best	Best	Poor	Poor
Water Quality	Good	Best	Good	Poor
HOA fee	$350	$500	$350	$0
Imagine you are standing in the places represented by the photos below, given the following attributes, which do you prefer?	◯ Horizontal Levee	◯ Living Shoreline	◯ Bulkhead	◯ Status Quo

How certain are you about your response to these questions?

1) Very Certain
2) Certain

3) Somewhat Certain
4) Neutral
5) Somewhat Uncertain
6) Uncertain
7) Very Uncertain

Repeat section above three more times with different attribute levels for the scenarios…

If you answered "Status Quo" for any of the above three questions, what is your primary reason?

1) River shoreline protection projects are not worth enough to me
2) I am not willing to pay anything for river shoreline protection projects
3) I do not believe the river shoreline protection projects will work as described
4) I do not believe I should have to pay for river shoreline protection projects

How likely do you think it is that this survey will influence actual decisions that are made on river shoreline protection?

1) Very likely
2) Likely
3) Neutral
4) Somewhat unlikely
5) Very unlikely
6) Not sure/ don't know

How likely do you think it is that this survey will influence funding and taxation for river shoreline protection projects?

1) Very likely
2) Likely
3) Neutral
4) Somewhat unlikely
5) Very unlikely
6) Not sure/ don't know

DCE - Pond - Scenario 1

In this section, you will be presented with three images of coastal resilient adaptations and you will be asked to indicate your preference for the photos. There will be several characteristics of each of the adaptations, such as cost, wildlife habitat, water quality, etc., which will influence your preference. These photos are actual places taken on the site and manipulated to include the adaptation. Please select your preference for the photo you like best. You will complete this question four individual times, however, the attributes will have different values. Please complete all four scenarios.

Scenario 1: Pond Enhancement

The following definitions are the coastal resilient adaptations that will be represented in the images:

Littoral Shelf: a sloped shelf planted with native plants to maintain cover and habitat.

Floating Wetland: artificial floating material for aquatic native plants to grow through, in the middle of deep ponds where plants can't reach the ground

The following attributes can be defined:

Fish and Wildlife Habitat – improving fish and wildlife habitat

- Best - strong support of healthy ecosystem (high habitat suitability for Marsh Wren)
- Good - limited support of ecosystem (medium habitat suitability for Marsh Wren)
- Poor - weak support of ecosystem (low habitat suitability for Marsh Wren

Water Quality - improving water characteristics for recreational use

- Best - high water quality index (pH, water temperature, and dissolved oxygen within a high range)
- Good - medium water quality index (pH, water temperature, and dissolved oxygen within a medium range)
- Poor - low water quality index (pH, water temperature, and dissolved oxygen out of range)

Additional HOA fee - additional monthly cost to implement coastal resilient adaptations, until design is paid in full

- $0 *to* $500

	Littoral Shelf	Floating Wetland	Existing Condition
Fish & Wildlife Habitat	Good	Best	Poor
Water Quality	Good	Best	Poor
HOA Fee	$75	$50	$0
Which would you choose?	◌ Littoral Shelf	◌ Floating Wetland	◌ Existing Condition

How certain are you about your response to these questions?

1) Very Certain
2) Certain
3) Somewhat Certain
4) Neutral
5) Somewhat Uncertain
6) Uncertain
7) Very Uncertain

Repeat section above three more times with different attribute levels for the scenarios…

Demographics:

What is the zip code of your primary residence? _____

What is your age? _______

How do you describe yourself?

1) Male
2) Female
3) Non-binary/third gender
4) Prefer to self-describe
5) Prefer not to say

What is the highest level of education you have complete?

1) Some high school or less
2) High school diploma or GED
3) Some college, but no degree
4) Associates or technical degree
5) Bachelor's degree
6) Graduate or professional degree

What best describes your employment status over the last three months?

1) Working full-time
2) Working part-time
3) Unemployed and looking for work
4) A homemaker or stay-at-home parent
5) Student
6) Retired

What was your total household income before taxes during the past 12 months?

1) Less than $25,000
2) $25,000-$49,999
3) $50,000-$74,999
4) $75,000-$99,999
5) $100,000-$149,999
6) $150,000 or more

What is your current marital status?

1) Married
2) Living with a partner
3) Widowed
4) Divorced/Separated
5) Never been married

Are you of Spanish, Hispanic, or Latino origin?

1) Yes

2) No

Choose one or more races that you consider yourself to be:

1) White
2) Black or African American
3) American Indian or Alaska Native
4) Asian
5) Native Hawaiian or Other Pacific Islander
6) Other

End of survey:

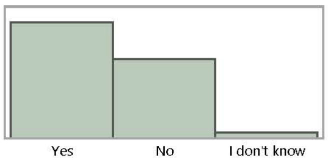
Do you have any additional comments? ______

Thank you. That concludes the survey.

Appendix C

Distributions

Had you heard of "green" infrastructure before reading the above information?

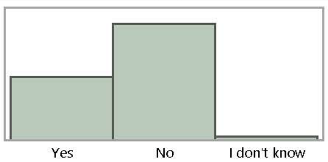


Frequencies

Level	Count	Prob
Yes	57	0.58163
No	39	0.39796
I don't know	2	0.02041
Total	98	1.00000

N Missing 95
3 Levels

Had you heard of "gray" infrastructure before reading the above information?

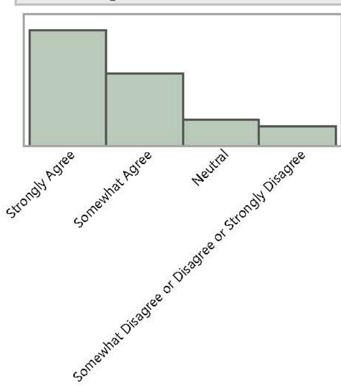


Frequencies

Level	Count	Prob
Yes	34	0.34694
No	63	0.64286
I don't know	1	0.01020
Total	98	1.00000

N Missing 95
3 Levels

Roads, bridges, and utilities will need to be fortified against sea level rise and storms 2

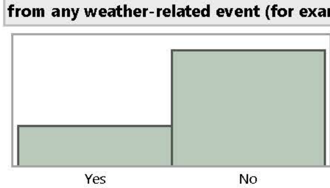


Frequencies

Level	Count	Prob
Strongly Agree	45	0.50000
Somewhat Agree	28	0.31111
Neutral	10	0.11111
Somewhat Disagree or Disagree or Strongly Disagree	7	0.07778
Total	90	1.00000

N Missing 103
4 Levels

In the next 12 months, do you think there is a chance that your home will flood from any weather-related event (for example, rain, storm surge, hurricane, etc.)?



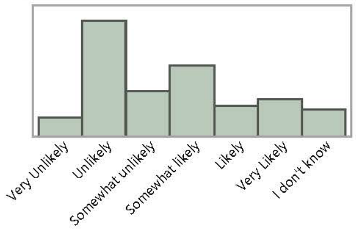
Frequencies

Level	Count	Prob
Yes	23	0.25275
No	68	0.74725
Total	91	1.00000

N Missing 102
2 Levels

Distributions

In general, how likely is it that your property will be flooded over the next 25 years?

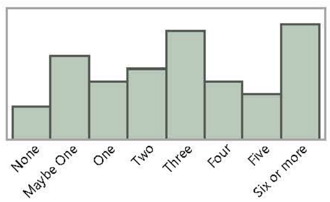


Frequencies

Level	Count	Prob
Very Unlikely	5	0.05435
Unlikely	31	0.33696
Somewhat unlikely	12	0.13043
Somewhat likely	19	0.20652
Likely	8	0.08696
Very Likely	10	0.10870
I don't know	7	0.07609
Total	92	1.00000

N Missing 101
7 Levels

How many major hurricanes (Category 3 or greater, with winds of 111 mph or greater, possibility of tornadoes, and storm surge of at least 10-12 feet) do you expect to impact over the next 50 years?

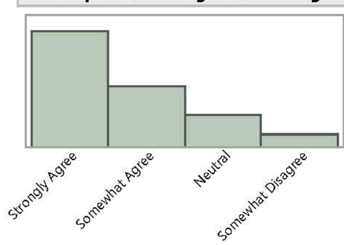


Frequencies

Level	Count	Prob
None	5	0.05618
Maybe One	13	0.14607
One	9	0.10112
Two	11	0.12360
Three	17	0.19101
Four	9	0.10112
Five	7	0.07865
Six or more	18	0.20225
Total	89	1.00000

N Missing 104
8 Levels

Erosion problems will get worse will get worse

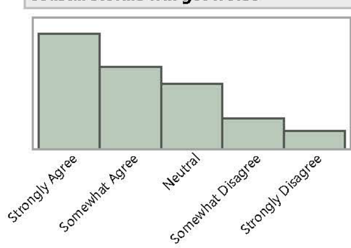


Frequencies

Level	Count	Prob
Strongly Agree	48	0.52747
Somewhat Agree	25	0.27473
Neutral	13	0.14286
Somewhat Disagree	5	0.05495
Total	91	1.00000

N Missing 102
4 Levels

Coastal storms will get worse



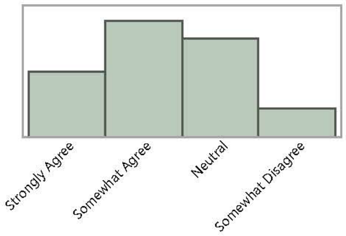
Frequencies

Level	Count	Prob
Strongly Agree	34	0.37363
Somewhat Agree	24	0.26374
Neutral	19	0.20879
Somewhat Disagree	9	0.09890
Strongly Disagree	5	0.05495
Total	91	1.00000

N Missing 102
5 Levels

Distributions

Some buildings will need to be moved or demolished to avoid flood and erosion risk

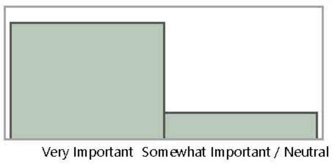


Frequencies

Level	Count	Prob
Strongly Agree	19	0.21111
Somewhat Agree	34	0.37778
Neutral	29	0.32222
Somewhat Disagree	8	0.08889
Total	90	1.00000

N Missing 103
4 Levels

Cost to my household 2

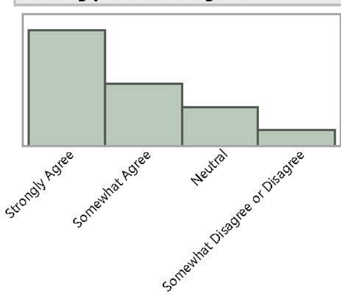


Frequencies

Level	Count	Prob
Very Important	79	0.82292
Somewhat Important / Neutral	17	0.17708
Total	96	1.00000

N Missing 97
2 Levels

Flooding problems will get worse 2



Frequencies

Level	Count	Prob
Strongly Agree	45	0.50000
Somewhat Agree	24	0.26667
Neutral	15	0.16667
Somewhat Disagree or Disagree	6	0.06667
Total	90	1.00000

N Missing 103
4 Levels

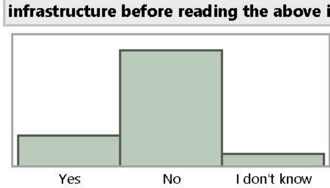
What monthly contribution would your household pay in addition to matched grant funds and cost share funds for design interventions to reduce coastal hazard risk? 2

Frequencies

Level	Count	Prob
$0	35	0.39326
$50	33	0.37079
$100 or more	21	0.23596
Total	89	1.00000

N Missing 104
3 Levels

Had you heard of "green/gray (hybrid)" infrastructure before reading the above information?



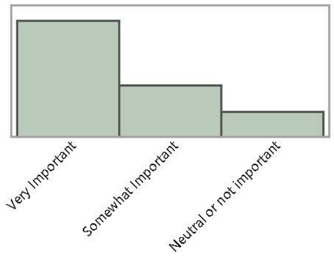
Frequencies

Level	Count	Prob
Yes	19	0.19388
No	72	0.73469
I don't know	7	0.07143
Total	98	1.00000

N Missing 95
3 Levels

Distributions

Providing water quality 2

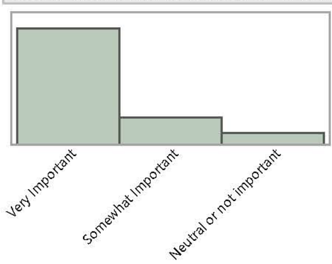


Frequencies

Level	Count	Prob
Very Important	57	0.60638
Somewhat Important	25	0.26596
Neutral or not important	12	0.12766
Total	94	1.00000

N Missing 99
3 Levels

Reducing High-tide (nuisance) flooding 2

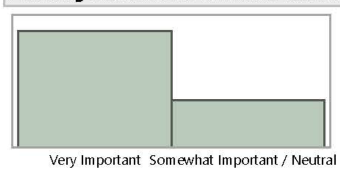


Frequencies

Level	Count	Prob
Very Important	69	0.75824
Somewhat Important	16	0.17582
Neutral or not important	6	0.06593
Total	91	1.00000

N Missing 102
3 Levels

Providing shoreline fish & wildlife habitat 2

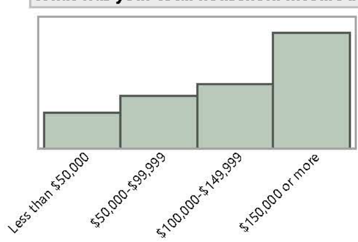


Frequencies

Level	Count	Prob
Very Important	67	0.71277
Somewhat Important / Neutral	27	0.28723
Total	94	1.00000

N Missing 99
2 Levels

What was your total household income before taxes during the past 12 months? 2



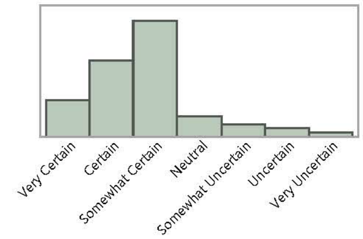
Frequencies

Level	Count	Prob
Less than $50,000	6	0.13043
$50,000-$99,999	9	0.19565
$100,000-$149,999	11	0.23913
$150,000 or more	20	0.43478
Total	46	1.00000

N Missing 147
4 Levels

Distributions

How certain are you about your response to these questions?

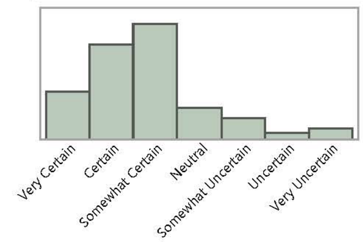


Frequencies

Level	Count	Prob
Very Certain	9	0.13235
Certain	19	0.27941
Somewhat Certain	29	0.42647
Neutral	5	0.07353
Somewhat Uncertain	3	0.04412
Uncertain	2	0.02941
Very Uncertain	1	0.01471
Total	68	1.00000

N Missing 125
7 Levels

How certain are you about your response to these questions? 5

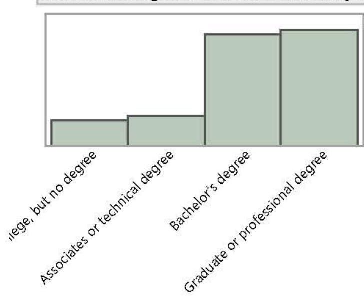


Frequencies

Level	Count	Prob
Very Certain	9	0.14516
Certain	18	0.29032
Somewhat Certain	22	0.35484
Neutral	6	0.09677
Somewhat Uncertain	4	0.06452
Uncertain	1	0.01613
Very Uncertain	2	0.03226
Total	62	1.00000

N Missing 131
7 Levels

What is the highest level of education you have completed?

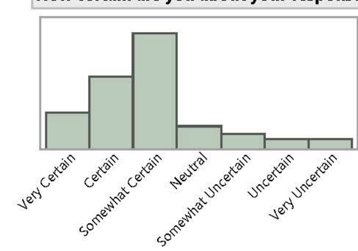


Frequencies

Level	Count	Prob
Some college, but no degree	5	0.08621
Associates or technical degree	6	0.10345
Bachelor's degree	23	0.39655
Graduate or professional degree	24	0.41379
Total	58	1.00000

N Missing 135
4 Levels

How certain are you about your response to these questions? 6



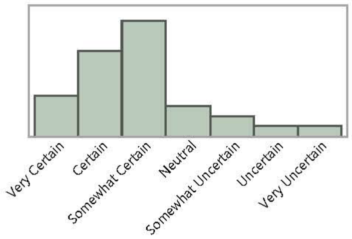
Frequencies

Level	Count	Prob
Very Certain	8	0.12903
Certain	16	0.25806
Somewhat Certain	26	0.41935
Neutral	5	0.08065
Somewhat Uncertain	3	0.04839
Uncertain	2	0.03226
Very Uncertain	2	0.03226
Total	62	1.00000

N Missing 131
7 Levels

Distributions

How certain are you about your response to these questions? 7

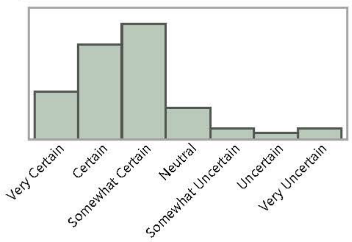


Frequencies

Level	Count	Prob
Very Certain	8	0.12903
Certain	17	0.27419
Somewhat Certain	23	0.37097
Neutral	6	0.09677
Somewhat Uncertain	4	0.06452
Uncertain	2	0.03226
Very Uncertain	2	0.03226
Total	62	1.00000

N Missing 131
7 Levels

How certain are you about your response to these questions? 8

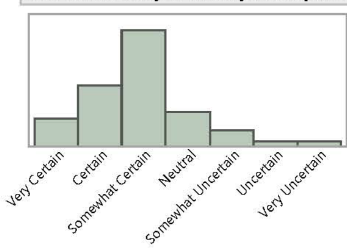


Frequencies

Level	Count	Prob
Very Certain	9	0.15000
Certain	18	0.30000
Somewhat Certain	22	0.36667
Neutral	6	0.10000
Somewhat Uncertain	2	0.03333
Uncertain	1	0.01667
Very Uncertain	2	0.03333
Total	60	1.00000

N Missing 133
7 Levels

How certain are you about your response to these questions? 2

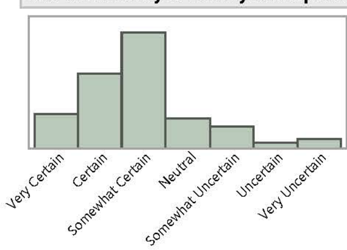


Frequencies

Level	Count	Prob
Very Certain	7	0.10145
Certain	16	0.23188
Somewhat Certain	31	0.44928
Neutral	9	0.13043
Somewhat Uncertain	4	0.05797
Uncertain	1	0.01449
Very Uncertain	1	0.01449
Total	69	1.00000

N Missing 124
7 Levels

How certain are you about your response to these questions? 3



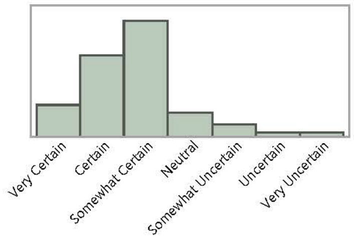
Frequencies

Level	Count	Prob
Very Certain	8	0.11594
Certain	18	0.26087
Somewhat Certain	28	0.40580
Neutral	7	0.10145
Somewhat Uncertain	5	0.07246
Uncertain	1	0.01449
Very Uncertain	2	0.02899
Total	69	1.00000

N Missing 124
7 Levels

Distributions

How certain are you about your response to these questions? 4

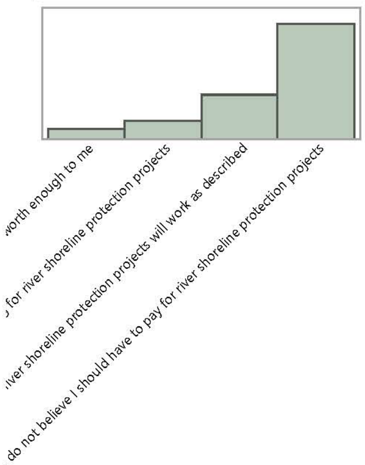


Frequencies

Level	Count	Prob
Very Certain	8	0.11429
Certain	21	0.30000
Somewhat Certain	30	0.42857
Neutral	6	0.08571
Somewhat Uncertain	3	0.04286
Uncertain	1	0.01429
Very Uncertain	1	0.01429
Total	70	1.00000

N Missing 123
7 Levels

If you answered "Status Quo" for any of the above three questions, what is your primary reason?

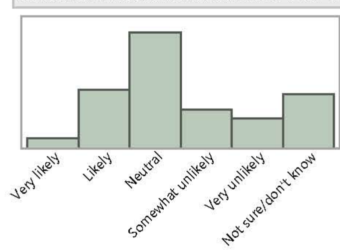


Frequencies

Level	Count	Prob
River shoreline protection projects are not worth enough to me	1	0.04762
I am not willing to pay anything for river shoreline protection projects	2	0.09524
I do not believe the river shoreline protection projects will work as described	5	0.23810
I do not believe I should have to pay for river shoreline protection projects	13	0.61905
Total	21	1.00000

N Missing 172
4 Levels

How likely do you think it is that this survey will influence actual decisions that are made on river shoreline protection?



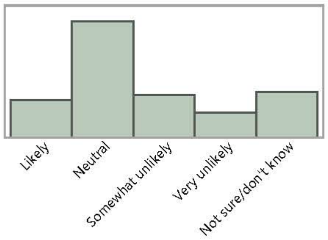
Frequencies

Level	Count	Prob
Very likely	2	0.03175
Likely	12	0.19048
Neutral	24	0.38095
Somewhat unlikely	8	0.12698
Very unlikely	6	0.09524
Not sure/don't know	11	0.17460
Total	63	1.00000

N Missing 130
6 Levels

Distributions

How likely do you think it is that this survey will influence funding and taxation for river shoreline protection projects?

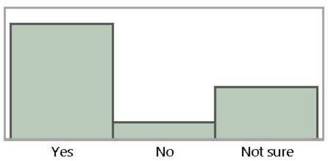


Frequencies

Level	Count	Prob
Likely	9	0.14063
Neutral	28	0.43750
Somewhat unlikely	10	0.15625
Very unlikely	6	0.09375
Not sure/don't know	11	0.17188
Total	64	1.00000

N Missing 129
5 Levels

Do you understand the above scenario and feel confident in offering feedback on your support for conventional gray, hybrid, and green riverbank infrastructure projects?

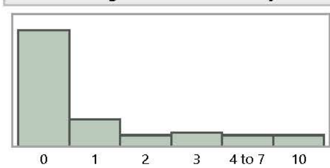


Frequencies

Level	Count	Prob
Yes	56	0.62921
No	8	0.08989
Not sure	25	0.28090
Total	89	1.00000

N Missing 104
3 Levels

Since you've lived in your current home, approximately how many times has there been flooding within 100 feet of your home (whether or not your home was damaged)? 2

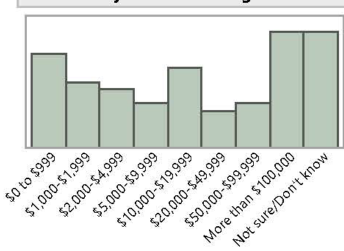


Frequencies

Level	Count	Prob
0	57	0.62637
1	13	0.14286
2	5	0.05495
3	6	0.06593
4 to 7	5	0.05495
10	5	0.05495
Total	91	1.00000

N Missing 102
6 Levels

Suppose a Category 3 hurricane (with winds exceeding 110 mph, possibility of tornadoes, and storm surge of at least 10-12 fe struck near your house at high tide. How much personal property loss (the value of contents) do you think your home would



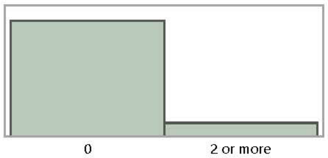
Frequencies

Level	Count	Prob
$0 to $999	13	0.14444
$1,000-$1,999	9	0.10000
$2,000-$4,999	8	0.08889
$5,000-$9,999	6	0.06667
$10,000-$19,999	11	0.12222
$20,000-$49,999	5	0.05556
$50,000-$99,999	6	0.06667
More than $100,000	16	0.17778
Not sure/Don't know	16	0.17778
Total	90	1.00000

N Missing 103
9 Levels

Distributions

How many of those times did you experience flood damage to your home? 2

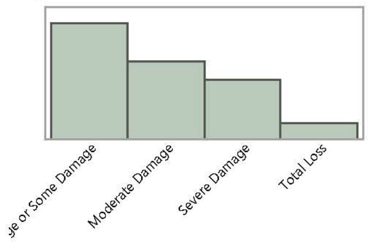


Frequencies

Level	Count	Prob
0	81	0.90000
2 or more	9	0.10000
Total	90	1.00000

N Missing 103
2 Levels

Suppose a Category 3 hurricane (with winds exceeding 110 mph, possibility of tornadoes, and storm surge of at least 10-12 feet) directly struck near your house at high tide. How much damage do you think your home would most likely suffer? 2

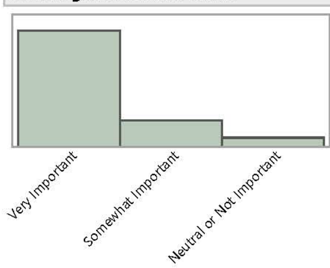


Frequencies

Level	Count	Prob
No Damage or Some Damage	39	0.43333
Moderate Damage	26	0.28889
Severe Damage	20	0.22222
Total Loss	5	0.05556
Total	90	1.00000

N Missing 103
4 Levels

Reducing Storm Flood Risk 2

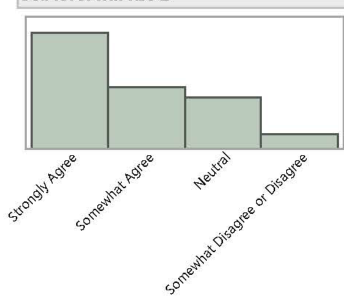


Frequencies

Level	Count	Prob
Very Important	74	0.77895
Somewhat Important	16	0.16842
Neutral or Not Important	5	0.05263
Total	95	1.00000

N Missing 98
3 Levels

Sea level will rise 2



Frequencies

Level	Count	Prob
Strongly Agree	43	0.47778
Somewhat Agree	23	0.25556
Neutral	19	0.21111
Somewhat Disagree or Disagree	5	0.05556
Total	90	1.00000

N Missing 103
4 Levels