

DO YOU HAVE WHAT I EXPECT? – UNDERSTANDING THE GAP BETWEEN LOCAL
GOVERNMENTS’ PLANS TO MITIGATE COASTAL HAZARDS AND PUBLIC
PERCEPTIONS

by

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A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Geography
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2021

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ABSTRACT

The New Orleans region of Louisiana has been at the front of coastal hazard and climate change research in recent years because of its high social vulnerability, influenced by its location on the Gulf of Mexico, socioeconomic profile, and general location below sea level. Municipal hazard mitigation must be sufficient not only in its coverage of the hazards that pose a threat to the region but also of the hazards that residents of this region are most concerned about. Resident perception of risk is a vital component of social vulnerability and can be utilized by residents and their municipality to increase resiliency against hazards. Because climate change is expected to intensify these threats, it becomes important to ensure that resident perceptions of risk are considered when developing municipal plans to maximize regional resiliency against major events. This research aims to identify a gap in the hazard mitigation process that can be closed to better prepare the community to handle coastal hazards. To achieve this, an online survey is distributed to the New Orleans metropolitan area to determine risk perceptions and expectations of the local government's action in response to coastal hazards and climate change. Policy analysis is conducted to identify the priorities held by municipal planners in these issues. Through research, it is found that, although there is no gap in the perception of risk and municipal mitigation of current coastal hazards that threaten New Orleans, there is a substantial gap between the municipal approach to climate change mitigation and the worry and expectation of action the residents hold regarding the future effects of climate change on the region. It is recommended that the approach to climate change is reconsidered on a municipal level and that

new small-scale personal resiliency incentives are promoted to maximize resiliency toward coastal hazards in the future for New Orleans.

LIST OF ABBREVIATIONS AND SYMBOLS

CPRA	Coastal Protection and Restoration Authority
FEMA	Federal Emergency Management Agency
OHSEP	Office of Homeland Security and Emergency Preparedness
RIM	Resilience Inference Measurement
SVI	Social Vulnerability Index

ACKNOWLEDGEMENTS

I would like to thank Dr. Wanyun Shao, my committee chair and graduate advisor, for her support in my research through undergrad and in my graduate studies. The opportunities and knowledge I have received from her have been instrumental in my understanding of social geography and helped me tremendously in the creation of this thesis. I would also like to thank my committee members, Dr. Appiah-Opoku and Dr. VanDyke, for their help in making this happen. Finally, I would like to thank my family, who supported me every step of the way.

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INTRODUCTION

Since the events of Hurricane Katrina in 2005, the city of New Orleans has been a frequent subject of study as to how vulnerability to coastal hazards and climate change affects the community and municipalities of the region. New Orleans is identified as a region with exceptionally high physical and social vulnerabilities in the face of current coastal hazards and intensifying hazards as a result of climate change (Emrich & Cutter, 2011). This is in part because of the location of much of the population centers of the New Orleans metropolitan area below sea level in addition to the fact that the region contains a substantial percentage of the population of Louisiana, which places a large population at direct risk (Griggs, 1994). The city of New Orleans as well as the southeastern region of Louisiana in general is most threatened by hurricanes and flood events in addition to increasing coastal water levels caused by sea level rise in the Gulf of Mexico (Cai *et al.*, 2016; Gotham *et al.*, 2018; Rogers, 2008). Not only is New Orleans particularly vulnerable to flood events due to the lack of natural drainage of rain and floodwater out of population centers, but erosion along the southern coast of Louisiana also results in the New Orleans region being exposed to the effects of sea level rise.

The combination of these factors produces a natural hazard vulnerability profile for the parishes consisting of the New Orleans metropolitan area that is considerably more extreme than any other region on the Gulf Coast (Emrich & Cutter, 2011). Trends identified for the effects of climate change on the region indicate that the intensity of coastal hazards will only increase. This emphasizes the knowledge and ability of the residents of the region to mitigate these hazards. A

well-prepared and sufficiently resilient community is best suited to address and handle coastal hazards when extreme events directly threaten the safety and property of the population (Combest-Friedman *et al.*, 2012). However, because of the large scale of many coastal hazards, residents are often unable to mitigate the threat posed by these hazards on their own.

While residents are capable of small-scale resiliency projects on their property, the majority of regional resiliency is the responsibility of coastal governments regarding coastal hazards. The municipality must be well informed about the needs of its residents as well as the worries regarding coastal hazards that are held in the general public (Griffin *et al.*, 2004). By doing so, the municipality can be capable of adequately adapting to the threat posed by the hazards despite social and physical variation present in the characteristics of the region (Birkland, 2001; Boruff *et al.*, 2005). To determine whether or not the perceptions of risk regarding coastal hazards held by the community are being adequately covered and managed by the government, the plans produced by the government relating to the mitigation of these risks must be analyzed. By doing so, the degree to which the community is both sufficiently satisfied and protected can be determined (Wachinger *et al.*, 2012).

If it is discovered that the risk perceptions and worries held by the residents are not properly addressed in the master plans and hazard mitigation plans of their respective parishes, then changes must be made to ensure that residents are adequately covered by their local government. If the threat of current coastal hazards is not sufficiently addressed, then the population of the metropolitan area may be unprepared to react to a major hurricane or flood event in the near future. If the threat of climate change effects is not sufficiently addressed, then the population of the metropolitan area may be subject to increasing intensities of extreme events as well as pressure from sea level rise from the Gulf of Mexico, which are on such a large scale

that adaptive mitigation would be difficult. As a result, it is vital that both preemptive and adaptive mitigation is explored to identify how the population can best be protected and their concerns are addressed when dealing with the threats posed by current coastal hazards and by climate change.

This research aims to identify a major gap between the risk perceptions held by residents of New Orleans regarding coastal hazards and the coverage of these hazards by municipal plans. Within the course of the study, three research questions are posed to identify this gap. First, it must be determined whether there is a substantial gap between the residents and municipal plans to begin with. Second, the location of the gap must be identified. Lack of communication and application can occur in the information gathering process, planning process, or conveyance of information back to the general public. Finally, it should be considered how the gap can be addressed. This depends on the subject matter that composes the gap, whether it be coastal hazards, climate change, or physical mitigation, and the location of the gap. Through these research questions, accurate and substantial analysis of the interaction between residents and their municipality can be completed and beneficial results can be applied to plans and future research.

If such a gap is not adequately addressed, the local governments of the region will lose the support of the public since the issues that residents worry about the most are not properly addressed. In turn, proper hazard mitigation would become unsuccessful in the full coverage of social vulnerability on large and small scales (Cutter & Emrich, 2006). This could result in New Orleans becoming unable to properly handle extreme weather events in the present in addition to the effects of climate change in the future. Regardless of how structurally prepared the city is, proper emergency response within the general public cannot be ensured if individuals are

unprepared and unmotivated to act in the event of a major hazard (Osberghaus *et al.*, 2010). In addition, without sufficient support from residents, necessary municipal structural and non-structural projects are not possible to undertake since the planning and execution of these projects often occur in tandem with individuals and the municipality. This is especially true of projects designed to improve social resiliency and reduce the social vulnerability of the region (Boruff *et al.*, 2005). To ensure that the New Orleans metropolitan area exhibits high resilience and is as prepared for future coastal hazards, such a gap between the residents and municipality must be recognized so that it can be addressed in future planning efforts.

BACKGROUND

The New Orleans metropolitan area consists of seven parishes located near the shoreline shared between the state of Louisiana and the Gulf of Mexico. Of these parishes, Orleans, Jefferson, and St. Tammany are selected for the survey conducted in this study, as they are the parishes that contain the suburbs closest to the city proper of New Orleans and received the most robust response rate in the online survey distributed to the metropolitan area. The metropolitan area has an estimated population of over 1,275,000 people as of 2017 (United States Census). The most populated areas in the metropolitan area are located below sea level, which along with the high population present in the city proper and metropolitan area results in New Orleans being considered a significantly vulnerable city. This city is vulnerability particularly when considering the threat of coastal hazards in addition to the relatively high percentage (61.1%) of residents in the civilian labor force and 24.6% poverty rate in the city, according to 2018 estimates by the U.S. Census Bureau. The Center for Disease Control and Prevention depicts the relative social vulnerability of the New Orleans metropolitan area. The Social Vulnerability Index (SVI) is measured on a scale of 0 – 1.

Table 1.

Selected parishes of the New Orleans metropolitan area with Social Vulnerability Index score and designation compared to the population of each parish in 2016

Data Source: <https://svi.cdc.gov/map.html>

Parish	2016 SVI Score	2016 SVI Designation	2016 Population
Orleans	0.7599	High	391495
Jefferson	0.5527	Moderate to High	436523
St. Tammany	0.3228	Low to Moderate	253602

The SVI values for many of the parishes encompassing the New Orleans metropolitan area are identified as being at levels of moderate to high vulnerability, with a large percentage of the population of the metropolitan area in parishes with an SVI value over 0.5, which indicates a minimum of “moderate to high” vulnerability (Table 1). This assessment of social vulnerability has also been the subject of scientific studies in the field of social geography. In a study conducted by Emrich and Cutter (2011), locations within the southern United States were studied with the intent to identify patterns in social vulnerability within communities, particularly those in coastal areas, when considering hazards related to climate change. In this study, the effects of drought, flood, hurricane, and sea level rise events were considered to determine location-based social vulnerability.

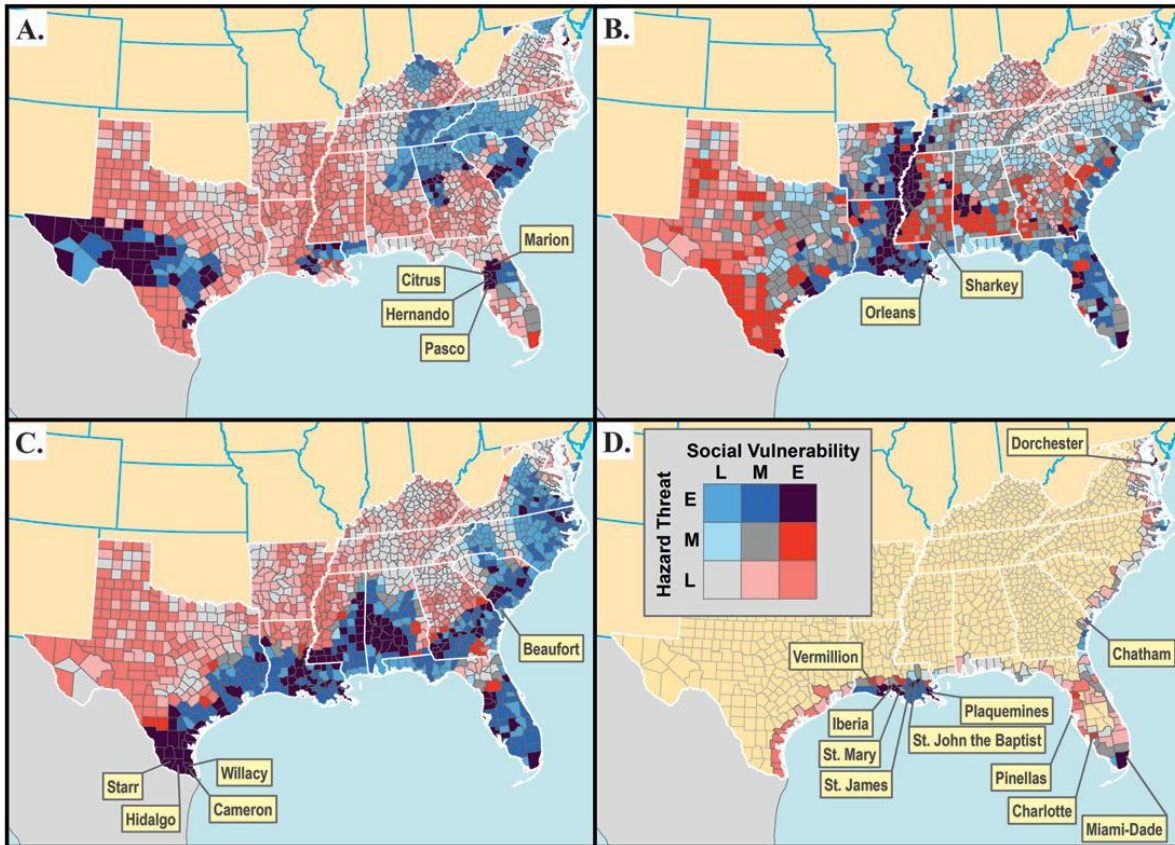


Figure 1. Place vulnerability to (a) drought hazard, (b) flood hazard, (c) hurricane wind hazard, and (d) sea level rise hazard. Note that southeastern Louisiana is one of the only regions along the Gulf Coast to register an elevated vulnerability score for all four applied hazards. Source: (Emrich & Cutter, 2011)

Of all of the regions considered in the study, the parishes composing the New Orleans metropolitan area are unique in that they are the only parishes or counties along the Gulf Coast that experience “elevated” hazard designations for all four hazards (Emrich & Cutter, 2011). This is affected in part by the location of New Orleans below sea level on the Gulf of Mexico surrounded by vulnerable wetlands but is also affected by the continuously increasing population of the New Orleans region. To further complicate matters, there is a high concentration of vulnerable demographic groups in the city. A larger population and more developed infrastructure in an urban area inevitably lead to a higher human and economic risk in the face of

coastal hazards (Griggs, 1994). This is especially true in the event of especially deadly individual hazard events, such as hurricanes.

In coastal regions of the United States, recent increased development has resulted in more economic and social damage during extreme events (Lawrence *et al.*, 2018). As a result, to understand the full effect of place-based risk on the city of New Orleans, individual trends in each of the major parishes composing its general metropolitan area must also be understood to ensure the most comprehensive analysis of New Orleans as a city at risk of coastal hazards. The city lies close to the Gulf of Mexico, being below sea level in the Mississippi River Delta. The city of New Orleans is actively engaged in hurricane and flood prevention in large part because of the residents' recent experience with catastrophic flooding caused by storm surge and intense rainfall during Hurricane Katrina in 2005. This experience has resulted in the community becoming much more aware of the risks involved with coastal hazards (Gotham *et al.*, 2018). The understanding of how the location of New Orleans increases its social vulnerability is significant to the future safety of the city because of the acute coastal erosion occurring along the Louisiana coastline downstream from the city intensified by the effects of sea level rise.

Survey Area of New Orleans, LA



Figure 2. Louisiana parishes within the New Orleans metropolitan area considered for this research

Source: US Census

This research considers three major parishes of the New Orleans metropolitan area. These parishes are Jefferson, Orleans, and St. Tammany. Jefferson Parish is a major suburb of the city of New Orleans, located directly to the east and southwest of the city proper, which is contained within Orleans Parish. These parishes border Lake Pontchartrain to the north and Jefferson borders the Gulf of Mexico to the south. St. Tammany is located across Lake Pontchartrain to the northeast of Jefferson and Orleans. Jefferson and Orleans Parishes also contain part of the Mississippi River, Jefferson in the northern region of the parish and Orleans in the southwest. Not only does this proximity to major littoral and riparian features characterize the parish's approach to spatial planning, but it also diversifies the mitigation required to adequately prepare the parish for an extreme event, particularly regarding flooding from surge or excess rainfall. Currently, these parishes have a system of natural and constructed levees located along the

Mississippi River to protect against regular floods from excess rainfall and near Lake Pontchartrain to protect against major floods from hurricane and heavy rainfall events that increase the water level in the lake (Rogers, 2008).

Jefferson Parish features a network of natural wetlands in the southern half of the parish that helps to protect against storm surge in addition to levees constructed to the south of many of the major unincorporated areas that contain the majority of the population in the parish. St. Tammany contains a network of wetlands along its border with Lake Pontchartrain to the south. Topographically, Orleans and Jefferson are similar, with much of the land within the parishes lying below sea level. This places a considerable emphasis on the drainage system in the parishes, which is designed to pump water out of the parish, primarily to Lake Pontchartrain, in the event of a major flood event (Rogers, 2008). Unlike the parishes south of Lake Pontchartrain, St. Tammany Parish is not located below sea level, and therefore prioritizes hurricane events more than general flooding events, although flooding associated with hurricane events remains a notable point of concern for residents of St. Tammany Parish.

The population of the region encompassing Jefferson, Orleans, and St. Tammany Parishes is 1,083,056 as of the annual estimate from 2019 (United States Census). Between the years 2000 and 2010, Jefferson and Orleans experienced a population decline, influenced in part by the parishes' experience with extreme coastal weather events during the 2005 Atlantic hurricane season, but the population has rebounded somewhat since 2010 at a rate of approximately one percent per year (Jefferson, 2019; New, 2018). St. Tammany, located north of Lake Pontchartrain and above sea level, did not experience much of the severe damage to property and decline in public health conditions caused by mass evacuation from the flooded parishes, so it did not experience as dramatic a drop in population after 2005 (Jonkman *et al.*,

2009). The population of the survey area is 57.16% white and 35.18% African American in addition to 47.81% male and 52.19% female (United States Census). In addition, the parish has a predominantly young but generally stable population. As with the other regions considered for the survey area of this research, these demographic factors are important to understand the trends of risk perception and expectation regarding the threat of coastal hazards among different demographic groups.

The city of New Orleans and its surrounding communities lie primarily below sea level, which has brought considerable attention to the threat of flood in the past because of the city's original construction on low-density sediment and continued use of the underground flood drainage system leading to subsidence (New, 2018). In response, the city has constructed and maintained a system of levees surrounding the city to prevent water, particularly floodwaters brought from hurricane storm surge, from entering the city. On most occasions, the levee system successfully protects the city from floodwaters. However, occasionally most notably during Hurricanes Betsy (1965), Camille (1969), and Katrina (2005), the levees failed in part or completely, which brought devastating floods to New Orleans.

In 1965, southeastern Louisiana was impacted by Hurricane Betsy, which made landfall near the southern border of Jefferson Parish. Water from the surge resulted in many housing developments in the New Orleans metropolitan being flooded. In 1969, Hurricane Camille made landfall in Louisiana east of New Orleans, with much of the damage associated with the event occurred in Plaquemines Parish to the southeast. Much of the most significant development in Louisiana occurred beginning in the 1970s, which resulted in far more people than before being exposed to the threat of coastal hazards, most importantly that of extreme hurricanes (Coastal, 2017). In 2005, New Orleans was hit by Hurricane Katrina, which breached the levees in

Jefferson and Orleans. It has been found that in the case of the failure during Hurricane Katrina, this was caused by a series of mistakes that occurred because the communication and operation system was ill-prepared for an event of such magnitude (Wetmore, 2007). This catastrophic flood event was the cause of much of the destruction and many of the fatalities during Hurricane Katrina, as areas near breaches experienced high flood depths and high rates of drownings (Jonkman *et al.*, 2009). Many communities in the metropolitan area maintain a series of water pumps to drain excess rainwater from the city in the event of an above-average event (GOHSEP, 2019). Under normal circumstances, this drainage system is sufficient to minimize water levels in the city itself, but when combined with the threat of storm surge from hurricane events, can become backed up, leading to flooding in communities located below sea level. As a result, an emphasis is placed on the simultaneous maintenance of the drainage and levee systems to prevent events such as those which occurred during Hurricanes Betsy, Camille, and Katrina from happening again in the foreseeable future.

The damage sustained during Hurricane Katrina in particular inspired comprehensive strengthening of the resiliency of the region, which includes preemptive measures such as the prevention of wetland degradation and further development of the individual parishes' levee system in addition to anticipated adaptive measures in the event of extreme events including improvements to the parishes' emergency communication system. Because of this constant threat of floods, New Orleans has a municipal flood plan in place to handle the possibility of future floods and hurricanes hitting the city, but less attention has been paid to the possibility of an increase in these threats influenced by climate change or by nearby shoreline erosion. This creates the possibility for future coastal events to inflict damage unforeseen or unprepared for by current city administrators but also allows for the preparation for such events if sufficient

attention is applied to the increasing threat to the city's population. Regional governments consider sea level rise to pose the most considerable immediate threat to the parish since continued sea level rise contributes to coastal erosion that damages protective wetlands along the southern coast of Louisiana (City, 2015; The, 2009). One important way that parishes in the New Orleans metropolitan area are protecting the economic safety of its population is through the promotion of affordable private flood insurance for the citizens of the region (GOHSEP, 2019). This provides an avenue for protection for individual property owners in addition to compelling the parish government to emphasize insurance promotion initiatives. As a region with one of the largest populations and economic strengths in the state of Louisiana, the protection of the health, safety, and welfare of the residents of the New Orleans metropolitan area remains a vital component of public planning for the local government, especially regarding the threat posed by coastal hazards.

LITERATURE REVIEW

To understand the actions that individuals, organizations, and governmental entities take toward addressing the threat of hazards, perception of risk regarding these hazards must first be understood. The development of risk perceptions is a result of the combination of knowledge, experience, and worry that an individual possesses about a hazard, which they can use as a base from which to prevent or restrict the negative effects of that hazard. In the case of New Orleans, this is most prevalent in the production of perceptions of risks of coastal hazards, notably hurricanes, floods, and sea level rise. The mitigation of these hazards requires an understanding of residents' perceptions of risk in New Orleans regarding these hazards since mitigation involves both increasing community resilience while decreasing community vulnerability. The best way for a region to accomplish this is to combine small-scale individual and large-scale municipal mitigation measures to ensure that residents are best prepared for the current threat posed by coastal hazards and future threats posed by climate change.

General Perception of Risk

General human perception of risk is defined as the intuitive judgments that individuals make to identify the threat posed by a hazard for which their advanced knowledge is lacking. The formation of risk perception is complex, involving many factors. In many cases, risk perceptions are influenced by information gathered from the media, which provides a secondhand account as to the general threat different hazards pose. Meanwhile, risk perceptions are also influenced by socio-demographic characteristics and other situational factors (e.g.,

physical features of the hazard, political context, etc.) that determine how an individual responds to hazards. It is through these factors that risk perceptions are formed.

Furthermore, the development of risk perceptions in an individual is also dependent on the proximity of the individual to the threat in addition to the strength of the signal sent by the occurrence or threat of the hazard. The more extreme the hazard potential and the closer hazard events are geographically and socially to the individual, the more likely the individual will perceive the risk posed by the hazard (Friesinger & Bernatchez, 2010). When shared by a population, the likelihood of the fear of the risk being addressed by governmental institutions or other social leaders is raised, especially when the fear is especially pronounced. As a result, it is important for these entities to not only understand public risk perceptions but also determine when fear of hazards merits regulation and mitigation to reduce public fear of the hazard, even if regulation or mitigation doesn't prevent the hazard itself from occurring (Rajimakers *et al.*, 2008). It is also important to note that, like governmental entities, the general public is not solely concerned with the loss of life, but also concerned for the property, health, and welfare of the individual. As a result, risk analysis should explore the effects of a hazard event on public perceptions of its related risk and impact to understand what the public prioritizes (Ho *et al.*, 2008). This is especially vital when considering the particular lack of information that the public has about certain hazards. Thus, there is a need to apply the critical analysis of reported and observed perceptions to ensure appropriate mitigation of these hazards with the intent to minimize the associated tangible and public mental threat.

When determining the impact of risk, it is important to distinguish between real and perceived risk. Real risk is the physical impact that an event has on a given study area or population at a given period and can be quantified for use in a study (Freudenburg, 1988). On the

other hand, perceived risk is the assumption of the impact that an event has that is held by individuals, especially laypeople. The processes of planning and policymaking most often make use of real risk since real risk is effective at minimizing the direct impact of individual and continuous events. However, the difference between real and perceived risk is not so significant that perceived risk can be ignored in favor of a purely objective approach (Freudenburg, 1988). Perceived risk influences public worry about a hazard, which indirectly affects their tendency to support municipal mitigation projects as well as undertake personal mitigation projects (Osberghaus *et al.*, 2010). This helps to build the overall resiliency of the municipality on both a large and small scale.

Perceptions of Risks Associated with Coastal Hazards

When considering theories of risk perception in response to coastal hazards specifically, research should consider the factors that influence the development of these perceptions. This particularly relates to factors in the southeastern United States that may contribute to the overall perception of hazards such as hurricanes, flooding, and sea level rise. The political climate of the United States has resulted in increased politicization of climate change, which results in variables such as political affiliation and ideologies becoming points of interest in coastal hazard studies (Shao & Goidel, 2016; Shao *et al.*, 2014). In general, existing studies have examined risk perceptions and resilience in coastal communities (Shao *et al.*, 2018) by investigating the factors that influence risk perceptions of the community (Combest-Friedman *et al.*, 2012). This is specifically accomplished through the use of population surveys or questionnaires. In some cases, differences in particular responses to threats posed by natural hazards can be caused by availability bias, even if the threat itself is a particularly well-known one to begin with. In the case of coastal hazards, this takes the form of availability bias through the widespread

communication of severe hazards (Shao *et al.*, 2017b). To illustrate, for major hurricane events that produce significant storm surge, which is a primary factor in coastal flooding during hurricane events, the communication of this information to residents in generally high-risk regions can motivate them to buy flood insurance voluntarily. In this case, the individual possesses a heightened awareness of the risk posed by major flood events not necessarily from their own experience, but also via the general communication of risk by authorities.

This becomes more difficult to predict in the case of more abstract threats, such as that of climate change. Fortunately, hazards that are related to or inflamed by climate change, such as sea level rise, are already acknowledged by coastal communities and policymakers. Perhaps more so than most other coastal hazards, public perceptions of climate change and sea level rise are influenced by socio-demographic factors, which makes the addressing of climate change by governmental actions more complicated (Nerlich *et al.*, 2010). This is especially significant because of great amounts of uncertainties regarding the threat of climate change and its direct relationship to specific natural hazards (Weber, 2006; Zehr, 2000). Climate change is generally characterized by extremes in addition to gradual changes, which provides complications for laypeople to understand and interpret the impacts of climate change (Aalst, 2006). In general, residents of coastal regions that exhibit high rates of sea level risk are less concerned about the magnitude of future sea level rise than those in regions that don't experience as dramatic of a trend and are likely influenced by reports of the potential of future trends in high-risk areas (Shao *et al.*, 2020).

Because of the close association between sea level rise and climate change, the attitude of an individual toward climate change has a significant effect on their perceptions of sea level change. This suggests that the public likely perceives sea level rise as a result of climate change

and, as a result, causes the perception of sea level risk to be influenced by their opinion of climate change. This also explains and contributes to the ongoing struggle with the divisive politicization of policy addressing climate change in the United States. In the US, individual perceptions of the threat, and in some cases, the existence, of climate change are highly correlated with political orientation. In particular, Republicans are less likely than Democrats and independents to believe that climate change poses a significant threat to humans (Shao *et al.*, 2014; Shao *et al.*, 2020). Because of the politicization of the threat posed by sea level rise and by climate change in general, public opinion regarding coastal hazards, especially those that are generally related to the effects of climate, are highly affected by one's political orientation and perceptions of climate change (Combest-Friedman *et al.*, 2012). An example of this is referring to the same process as "sea level rise" and "sea level rise influenced climate change" to determine how much the association with climate change affects individual perception, and ultimately understanding, of the threat.

The development of risk perceptions of coastal hazards in a population naturally results in a pressure to act to accommodate the feelings of fear associated with the presence of the risks themselves. Individuals who perceive an increased risk posed by a particular hazard are more likely to act to mitigate the impact of the hazard or reduce their perceived risk (Osberghaus *et al.*, 2010). The promotion and implementation of preemptive measures in response to these threats posed by coastal hazards, when accomplished, can result in a more resilient coastal community. A well-prepared and resilient community is best suited to address the risk posed by coastal hazards and cope with the outcomes when extreme events threaten the safety, well-being, and property of the community (Lawrence *et al.*, 2018). These measures are addressed both by private entities, such as residents or businesses, or public entities, such as municipalities or

interest organizations. In the case of a coastal city such as New Orleans, a significant avenue for private mitigation is the purchase of flood insurance to protect the monetary value of property. Individuals who possess heightened risk perceptions of flooding and hurricane events are more likely to voluntarily purchase flood insurance (Shao *et al.*, 2017b). However, since flood risk is not the only threat posed by extreme coastal events, it is important to consider other risks associated with these threats, such as wind damage, for which the damage potential to the individual is highly dependent on the individual's circumstance. For instance, the threat varies depending on how many trees are present on and near the individual's property.

Personal exposure to a threat has been shown to play a less important role in the perception of more abstract risks, such as climate change, than public exposure, which is the collective impact of an event on a community. In the case of New Orleans, the public possesses a considerable perception of the risk of hurricane and flood hazards, which contributes to an individual's perception of risk even if they have not experienced these events personally, such as if they have recently moved to the city. In contrast, this dynamic is the opposite for more concrete risks, such as extreme weather events, in which case personal exposure is more important in the development of perceptions of risk than public exposure (McDaniels *et al.*, 1992). This is likely influenced by the fact that individuals can have personal experience with well-defined, tangible hazards such as hurricanes, but rely on experts for more abstract risks that may not have any current significant effect, despite how much of an effect they may have in the future on the region of interest. This is supported by the construal-level theory, which states that concrete hazards more than abstract hazards are perceived as imminent spatially and temporally by an individual (Liberman & Trope, 2010). However, it is important to note that simply providing information about a threat to a population is not enough to encourage them to take

preemptive or adaptive measures to alleviate their fears of the threat. This is because these actions are inspired by both information and motivation (Zaller, 1992). In addition, as extreme weather events caused by climate change continue to intensify in the future, approaches to policy and planning must change along with it to ensure that the population remains informed and prepared since necessary adaptation and preparation continues to change along with the development of the risk associated with the hazards (Macintosh, 2013).

Mitigating Risk Perceptions

Interpreting risk perceptions

Risk perceptions should be considered at an aggregate level to inform designing and implementing public policies. It is the expectation that the government considers the public's concerns in the development of public policies. The policies and plans developed by the local government of a coastal region to address coastal hazards must be analyzed to determine whether or not the corresponding community is sufficiently protected and whether or not these policies and plans have met the expectation of the community. This is especially important to ensure that the community is being adequately protected from extreme hazards for which individual households and property owners may be unable to adequately protect themselves (Wachinger *et al.*, 2012). Accordingly, this requires a solid understanding of public risk perceptions and risk factors that contribute to the formation of these perceptions. While doing so, the context in which the perceptions are developed should not be dismissed or understated. Contextual risks influence individual risk perceptions and long-term policy support for risk mitigation. It is significant to understand the aforementioned relationship since the contextual factors are often excluded from the consideration of individual risk perceptions and policy support. As a result, insufficient communication is made to ensure that adequate adjustments are made. This suggests that

seemingly isolated and insignificant individual perceptions of risk should be considered in the development of policy, especially when considering contextual factors. This is because the understanding of this relationship between environmental context, individual perception, and resulting policy is not easy to supplement with any other step in the policy development process (Shao *et al.*, 2017c). Meanwhile, it is also important to understand that, when contributing to the development of policy, that risk perceptions cannot provide a significant source of authority on their own and must be considered along with other factors to influence the process of responsible policy creation.

Applying risk perceptions to resiliency measures

While risk perception can be crucial to understanding community vulnerability and resiliency, external factors that affect individual perceptions of risk are likewise important in contextualizing the frame of reference held by the research population. Risk perceptions by themselves are somewhat weak predictors of individual and governmental protective behavior in response to natural hazards (Bubeck *et al.*, 2012). For one, existing studies consider the spatial location of respondents as a factor in the development of risk perceptions among coastal residents, as the proximity to a coastline or lakefront is known to contribute positively to the perception and concern regarding the risk of water-based hazards (Friesinger & Bernatchez, 2010; Scyphers *et al.*, 2019).

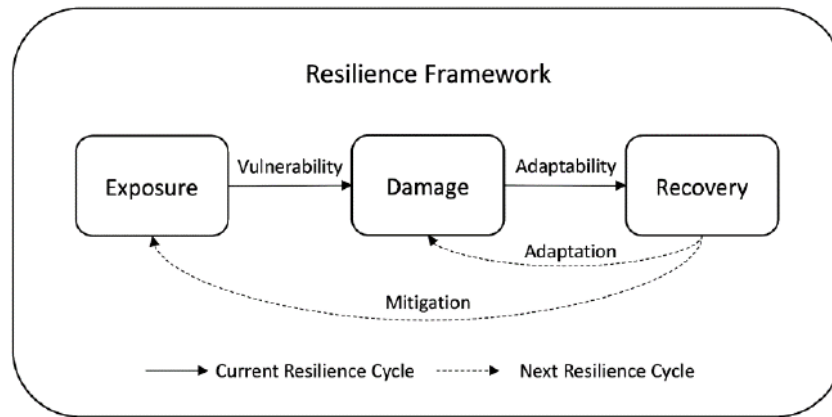


Figure 3. *Resilience Inference Measurement (RIM) framework*
 Source: (Lam *et al.*, 2016)

Personal experience with flood events is significantly related to higher perceptions of risk in individuals, particularly when those individuals suffered personal damage to their health or property (Gotham *et al.*, 2018). Since New Orleans is located in a region that experiences a very high rate of extreme weather events including tropical cyclones, it can be expected that the population will have some direct experience that would raise their awareness of and heighten their perceptions of risks posed by these events. Experience with an extreme event serves as a major factor in further adaptation and mitigation against similar events in the future, so an understanding of experience with hazards is vital to ensure individual and community resilience (Fig. 3). This is expressed in the resilience inference measurement framework, which identifies the relationship between exposure, damage, and recovery in identifying community vulnerability and planning adaptive and predictive mitigation when considering the potential impacts of similar events in the future (Lam *et al.*, 2016).

Fear of a hazard is not necessarily the factor that is most associated with the desire to learn more information about the hazard. Rather, worry about the hazard has been shown to influence the pursuit of information. This is likely because worry carries a more rational

approach to a threat than fear, which can tend to spawn from assumptions (Griffin *et al.*, 2004). Since coastal hazards are known by the population of the region to be a significant threat, the desire for more information tends to be high, which results from an elevated perception of risk. As individuals who perceive a heightened degree of danger from a hazard are more likely to believe that they require more information about the hazard to further guide their response (Griffin *et al.*, 2004). This is especially helpful when considering mitigation plans concerned with public education and outreach since individuals who are more worried about a hazard and those who feel pressured to stay educated about the hazard are more likely to believe that they require more information to sufficiently respond to the threat posed by the hazard (Griffin *et al.*, 1999; Griffin *et al.*, 2004). These individuals are likely to be more accepting of vital information concerning the risk that can improve their preparedness and resiliency. Further, this desire for information is contingent on the motivation of the individual to reduce their uncertainty of the hazard, which will in turn improve their perception of the risk posed by the hazard (Sommerfeldt, 2015).

Socio-demographic characteristics

A major set of variables that are known to correlate with individual perceptions of risk regarding coastal hazards are socio-demographic characteristics. The importance of demographics in risk perception is exemplified by the testing for this information in a great deal of scientific research regarding the topic. When considering the vulnerability and resilience of a population, risk perception and socioeconomic variables are both useful for identifying trends exhibited by the population (McDaniels *et al.*, 1992). Some variables are more significant in determining risk perceptions than others, however. For example, women with low income are shown to possess heightened perceptions of risk related to coastal hazards, particularly when

considering flood events, compared to men and individuals with higher income (Gotham *et al.*, 2018). Conversely, homeownership status and household composition are not generally shown to be significant predictors of risk perceptions related to coastal hazards (Gotham *et al.*, 2018). The education of an individual is also a somewhat weak negative predictor of perception of risk, being identified as a significant factor in some studies but not in others (Gotham *et al.*, 2018). Some studies show that an increase in overall education correlates with lower perceptions of risk, caused by less worry about abstract threats, but this relationship varies between studies. This can, in part, be explained by the fact that individuals residing in areas that possess heightened levels of hazard risks typically possess lower socioeconomic status and more personal disaster experience which, while related to knowledge of the threat posed by coastal hazards, is unrelated to the general formal education of the individual (Ho *et al.*, 2008). Political ideology is also a significant contributing factor to coastal and climate-related risk perceptions, especially since the politically divisive 2016 presidential election and the resulting partisan questioning of scientific reports in subsequent years (Long *et al.*, 2020). However, because these individual-level variables tend to be very place-specific, they continue to be tested in many risk perception projects to develop a more comprehensive understanding of their exact effects on risk perception, especially when considering place-specific factors.

Personal Actions

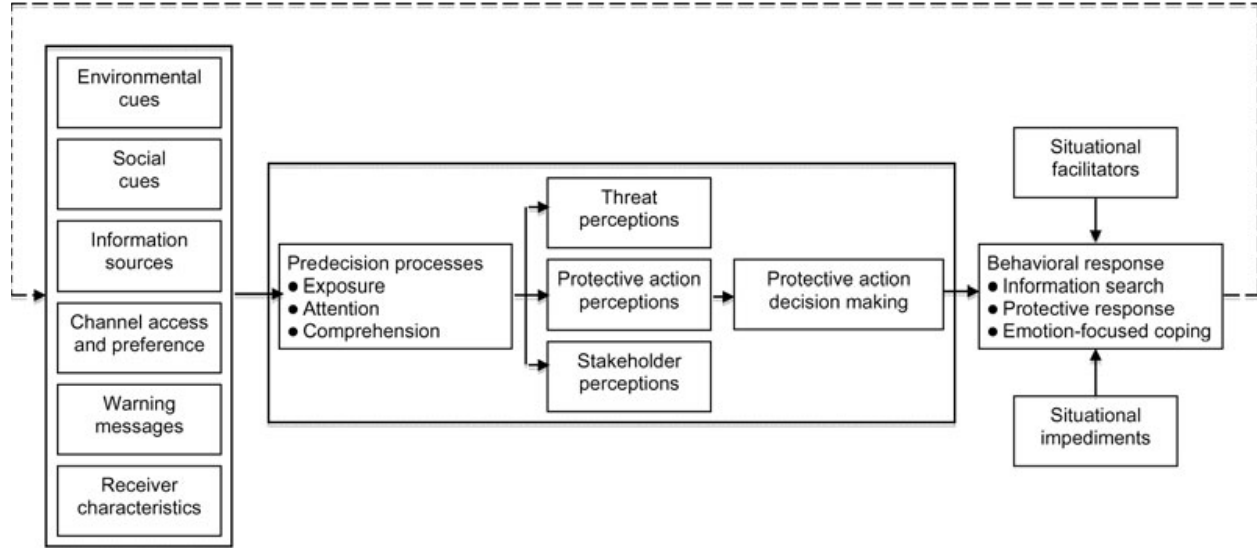


Figure 4. *The flow of information from the source to the individual in the influencing of action.*
Source: (Lindell & Perry, 2012).

To understand the actions that individuals take to alleviate their worry of identified risks, the process of decision-making based on the presence of risk must be applied through the protective action decision model (Lindell & Perry, 2012). This model identifies the flow of information processing, which originates from available direct and indirect sources and is then processed by the individual. The decision is also likely determined by preexisting knowledge and perceptions held by the individual before any action is taken by the individual based on the decisions made regarding the risk (Fig. 4). Specifically, an individual first identifies and assesses the risk associated with a hazard (Lindell & Perry, 2012). After this, a potential action to be taken in response to the risk is identified and assessed by the individual before being implemented. Upon implementing a response to the risk, the individual then determines whether or not the action taken was sufficient and necessary, which influences their subsequent applications of the action decision process. This process reveals that an important factor in the

development of risk perceptions and resulting action based on these perceptions is the knowledge of hazards and their potential consequences in the first place.

Gathering information

In many cases, perception of risk built on the worry of a hazard is indicative of a desire to learn new information about the hazard, if not an existing lack of knowledge of that hazard to begin with. When considering abstract natural threats such as climate change, individuals have been observed to develop their personal views on the threat based on existing societal or cultural perceptions of the issue in addition to experience with natural hazards (Connor & Higginbotham, 2013). Much of the information that people apply toward the threat of hazards in the development of their risk perception is knowledge gained specific to the context in which the threat is observed or imagined and is significantly less related to an individual's general pool of knowledge. While their level of education helps allow an individual to easily process information related to the hazard, this does not necessarily influence their motivation to seek further information about the hazard. This is partially supported by the fact that, when considering the impact of demographic factors, educational achievement is generally found to be uncorrelated specifically to the processing and non-routine seeking of information for the development of perceptions of risk, since educational achievement is not generally indicative of the individual's knowledge of a specific topic, such as natural hazards (Griffin *et al.*, 1999). As a result, when understanding how individuals collect and process information, the motivation and perspective of these steps are important to consider.

Individuals who require more information to cope with a given risk are more likely to seek information regarding this risk in a more non-routine manner and more likely to put effort into the processing of this information to apply it to their own lives and to improve their safety

(Griffin *et al.*, 1999). When collecting information, the general public has been shown to recollect past observed events, as individuals are noted to generally be able to identify trends when perceiving the reality and threat of climate change rather than relying on current objective environmental conditions (Shao & Goidel, 2016). The ability to identify past trends and observe a noticeable increase in hazard intensity and frequency in the recent past is more influential in the development of their perception regarding this trend than an observation of current conditions. This is because it is difficult to identify a trend relating to environmental change when observing only one point in time. However, data gathering and interpretation by the individual is nonetheless reliant on one's personal view, no matter how objective their intention to mitigate their fear of the risk itself is. When collecting information, the source from which facts are procured is important. Individuals are more likely to identify a meaningful pattern over time from news sources when they perceive the sources positively and are less likely to actively process information from sources if they hold negative biases against them (Griffin *et al.*, 1999). This negative bias can develop if the individual believes the news source itself to be biased or sensational in a way or to a degree that corrupts its ability to objectively convey vital information. This bias can later develop into an altered lens through which individuals perceive physical events. When considering local weather conditions, individuals are influenced more by political affiliation than by objective weather events. Specifically, Democrats are more likely than Republicans to perceive intensification in coastal hazards such as hurricanes and flood events in addition to general weather patterns (Shao & Goidel, 2016). These are all important variables to consider when applying public perceptions of risk to mitigation policies about meteorological and other physical coastal hazards, as these factors all contribute to public opinions as to what should be done in response.

Personal resiliency projects

More tangible actions that can be taken by individuals are that of private fortification of structures and their resiliency plan in the event of an extreme event. Homeowners and other general property owners can physically develop the structural integrity of their properties in the event of an extreme event (Bubeck *et al.*, 2012). This includes but is not limited to building retrofits, filling basement spaces, strengthening the structure's outer envelope, and elevating structures in at-risk zones. Retrofitting is the process by which new advances are made on older, existing structures or systems to strengthen or optimize them. An example of retrofitting is the development of a backup energy system in a critical facility such as a shelter or hospital to ensure that power remains available even during a significant natural hazard event. Basement filling involves the physical filling of underground basement space with sediment or other materials and is employed when the water table underneath a structure is especially high and threatens to flood the basement in minor events. In addition, the structure of the building itself can be improved by replacing or reinforcing it with stronger and more resilient materials that can hold up to extreme events. Finally, the elevation of structures is employed primarily in regions with extremely high flood risk, such as that found in New Orleans. In this case, the entire structure is placed on stilts or other structural devices to minimize the damage done during events that bring high floodwaters. Structural elevation is an expensive procedure but is often promoted and subsidized by local and state authorities, as is the case in Louisiana, because of how effective the process is in the reduction of general structural damage from extreme flood events (Jefferson, 2020).

Retrofitting and elevation projects are particularly supported by municipal groups, which provide subsidies for successful development projects and even undertake these projects

themselves as public programs in particularly at-risk zones, including those identified as being at elevated risk during 100-year events. Jefferson, Orleans, and St. Tammany Parish all include retrofitting and elevation projects in their hazard mitigation plans, which are commonly applied as subsidies to property owners who undergo development, municipal projects on public land, and the use of eminent domain to ensure that high-risk zones are sufficiently managed in the threat of hazard events. In addition to construction actions, private residents can take actions to improve their preparedness in the event of an emergency. These include methods of resisting floodwaters, one of the most dangerous threats to citizens of New Orleans, by acquiring sandbags and boards to close potential weaknesses on their property and to prevent floodwaters from reaching their house (Ahmad & Afzal, 2020). In addition, measures can be taken to improve the ability of the household to persevere during long periods of damage, such as those in which power and food are unavailable, by procuring a generator, stocking emergency supplies, and modifying the household's general plan of action in the event of a hazard to ensure that responsible steps are taken in the moment (Bubeck *et al.*, 2012). However, many citizens are restricted in the mitigation actions they can undertake on their own, typically because of limited resources and funds. Therefore, they have to rely on their municipalities to provide resources and services that they are unable to.

Municipal Actions

While many individuals take steps toward risk mitigation themselves, there is only so much that they are capable of. In many cases, individuals can only operate on a scale large enough to improve the resiliency of their households and have little impact on the development and implementation of local, municipal, and regional policies in addition to the application of mitigation measures and infrastructural development (Parvin *et al.*, 2008). Rather, these responsibilities fall on the respective municipality, which is tasked with managing the needs and resiliency of its residents. The municipality must be well informed about the hazards that threaten its residents in addition to the specific needs of the residents. This allows it to adequately establish preemptive and adaptive measures in response to the threat posed by these hazards (Birkland, 2001). In doing so, the social vulnerability of the region can be reduced, especially when considering natural hazards that are capable of causing property damages and casualties among the communities within the municipality.

It is important to emphasize the scale of knowledge and the level of detail considered when planning mitigation actions. In the case of coastal hazards, the neglect of small details of local implementation of preventive measures can affect the understanding of the policy coverage and the approach to major hazards, which can create an issue when attempting to understand the stance on these issues held by the population (Flannery *et al.*, 2015). By identifying specific aspects of communities, mitigation can be made more effective in the reduction of social vulnerability for those communities. Ignoring these individual factors and small-scale patterns can result in a false sense of security for the community since they are technically covered by mitigation actions but potentially not to a degree sufficient enough to protect their households. This can potentially have the unintended effect of actually increasing social vulnerability in the

wake of a particularly intense hazard event that the community was unprepared for despite their assumptions regarding their vulnerability (Cutter & Emrich, 2006).

When considering the increasing vulnerability to extreme events in the context of climate change and coastal hazards, it becomes vital to adopt effective municipal planning in the process of overall disaster risk reduction (Aalst, 2006). It is also vital to ensure that measures are not identified and pursued based simply on the identification of the problem and leaving the rest to the individual since social dynamics are too complicated to allow for this to be a viable option. In the United States, this is especially important when considering coastal hazards, which are frequently consciously or unconsciously viewed in a political light by individual citizens (Shao & Goidel, 2016). Therefore, it is important to address partisan resistance when promoting and implementing public policies when addressing coastal hazards, as raising awareness is insufficient to convince the general public as to the need for mitigation (Shao & Goidel, 2016). These potential shortcomings in the approach to planning and the communication of public information must be identified so that individuals can continue to be protected and to continue to be well-informed about developing and changing hazards (Nicholls & Mimura, 1998). It is also important to seriously consider input from individuals regardless of their assumed knowledge or political affiliation since a common mistake in public understanding is the assumption that the general public is not motivated to explore scientific information and educate themselves, which is not accurate (Ungar, 2000). This can be attained in part by the promotion of social meeting spaces, as research has shown that these spaces are vital to strengthening the capacity for hazard knowledge, comprehension, and response by communities. This provides an important avenue for developing community hazard responses, especially in urban settings (Bott *et al.*, 2019).

In some cases, projects are not created and promoted by the municipal government, but by the state. In the case of Louisiana, many projects related to coastal resiliency and recovery from extreme events are addressed by the Office of Homeland Security and Emergency Preparedness and the Coastal Protection and Restoration Authority. The projects developed by these state-level governments are typically done so with the entire state of Louisiana in mind. This both allows for projects that directly and indirectly benefit the coastline and landscape of New Orleans to be undertaken, often with considerably more available resources than those realized on a municipal level, but it also assists in enhancing the surrounding regions of the city (GOHSEP, 2019). This helps to reduce indirect effects like downstream sediment pollution and water volume that other regions can have on the city. The municipal government of New Orleans normally has little influence on the surrounding area due to being out of the jurisdiction of the parishes composing the metropolitan area of the city. These groups also maintain local-scale initiatives that the metropolitan area also promotes, notably those related to public education and land development (Coastal, 2017). Through the continuous cooperation between the various levels of government in Louisiana, the resilience of the community and city of New Orleans can be maintained into the future, even when pressured by extreme coastal hazard events.

METHODOLOGY

When developing the survey to be distributed to residents within the New Orleans metropolitan area, many of the question items considered were based on some previous research related to the residents' perceptions of risk associated with coastal hazards (Shao & Goidel, 2016; Shao & Kam, 2020; Shao *et al.*, 2020; Shao *et al.*, 2017a). Other survey items relating specifically to the implementation of projects were based on similar research or developed for the survey conducted for this research (Shao *et al.*, 2017c). The survey questionnaire, included as an appendix to this report, was designed to address three primary subjects: demographic and background information, perceptions of risk, and perception of governmental actions and accountability. An efficient approach to perceptions and physical effects of climate change and associated coastal hazards requires a high degree of attention to be paid to questions of scale, particularly when addressing the effects of associated risk perceptions with specific opinions of governmental policy approach. By targeting individuals who are physically within or adjacent to regions and zones of considerable concern in the New Orleans region of Louisiana, it was ensured that responses gathered from individuals within the survey sample would be relevant and representative of the residents of the New Orleans metropolitan area (Brace & Geohagen, 2010). A particular zone of interest was the Special Flood Hazard Zone designated by the Federal Emergency Management Agency (FEMA). The survey included two filter questions to ensure that respondents were paying attention, as straightlining by respondents results in poor data quality (Smith *et al.*, 2016). All 446 individuals who responded as residents in Jefferson,

Orleans, and St. Tammany Parishes answered these filter questions correctly, so no respondents were excluded for this reason.

The survey was distributed by Qualtrics digitally to the New Orleans metropolitan area. Respondents were compensated for their time participating in the online survey. The geographic location of each respondent was determined by the zip code where the respondent resided, with responses from individuals located outside the determined range of zip codes not included in the final report. During the duration of the survey fielding period, the range of accepted zip codes was increased to increase the response rate. This resulted in the number of parishes accounted for in the original data collection process increasing to nine. Once the data collection period concluded, the survey results were compiled in a report by Qualtrics, which was then analyzed for the variables tested in the statistical analysis portion of the research. The total number of respondents included in the original survey was 520 individuals. It was discovered that many of the parishes included in the survey were represented by a small number of individuals, in many cases under 10 respondents per parish, so the scope of the parishes accounted for in the statistical analysis were reduced to Jefferson, Orleans, and St. Tammany Parishes, which combined for a total of 446 respondents. Of these respondents, 168 were located in Jefferson Parish, 204 were located in Orleans Parish, and 74 were located in St. Tammany Parish. These parishes are notable as those closest to the city proper of New Orleans, and also contain the largest populations of the suburbs designated within the New Orleans metropolitan area according to the US Census, accounting for almost a quarter of the population of the state of Louisiana. To correspond to the geographic extent of the survey, the scope of the policy analysis was focused on the hazard mitigation and comprehensive master plans for these three parishes.

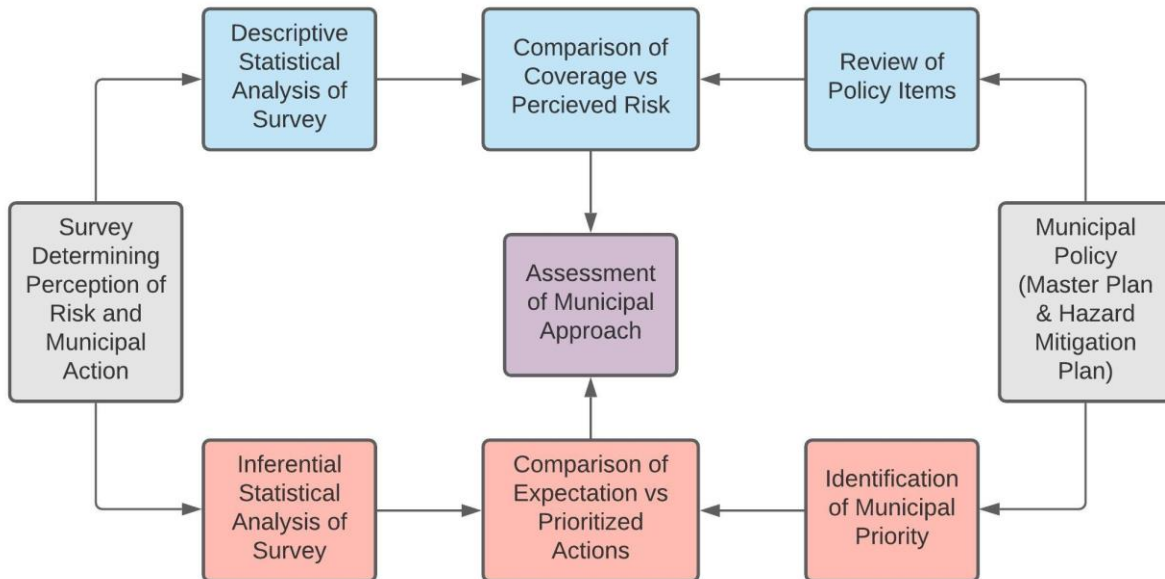


Figure 5. Flowchart visualizing the combination of survey and policy analysis during the research process.

Survey analysis and policy analysis were conducted separately, with key concepts identified during survey analysis explored in more detail during the analysis of each parish's hazard mitigation plan (Fig. 5). This was done because the project categories that were identified during statistical analysis represent those that respondents were most likely to convey specific opinions about. The comparison of municipal priority of mitigation incentives, for example, was more likely to be represented in the survey results by respondent support of mitigation incentives rather than other factors. To determine the impact of these other factors, inferential statistics were used to determine the underlying correlations between variables to identify how factors identified within the survey related to expectation and support of the municipal policy. By doing so, the degree to which individual perceptions of risk regarding the threat of coastal hazards in the municipal approach to adaptive and preemptive mitigation was assessed.

Survey Analysis

Independent variables

The first set of independent variables considered for data analysis were the demographic characteristics collected in the survey. These variables were used as control variables in addition to the creation of a probability weight for the survey population to be applied to statistical analysis later. First, age was measured ranging from 18 to 65+ years, which was recorded on a scale from 1 (18-35 years) to 4 (65+ years). It has been documented that age is negatively correlated with concern about climate-related risks, which includes the intensification of hurricanes and flooding and may further contribute to individual reactions relating to these risks (Shao *et al.*, 2017b). Second, the gender of the respondents was measured as male or female and was coded as a binary variable (Female = 1, Male = 0). This variable is particularly important, as females are generally more likely than males to express an elevated perception of risk regarding environmental and natural hazards (Shao & Goidel, 2016). Third, the reported race of respondents was measured as White, African American, Asian, and Other. Of these categories, the vast majority of individuals identified as white or African American, so race was calculated as a binary variable (African American = 1, Other = 0). In past studies, racial minorities have been evaluated to exhibit greater concern about environmental hazards, which is attributed to the fact that communities that are predominantly populated by racial minorities are more frequently subject to extreme environmental hazards (Elliott & Pais, 2006; Shao *et al.*, 2017a).

Fourth, the reported highest attained education level by the respondents was measured ranging on a scale from 1 (“less than high school”) to 7 (“doctorate”). The effect of education on risk perception is dependent on individual conditions, with general trends holding that education is positively correlated to mitigation policy support (Brody *et al.*, 2008) but negatively correlated

to general concern regarding environmental hazards (Shao & Goidel, 2016). In some cases, however, educational achievement is shown to be uncorrelated with perceptions of risk, with contextual information proving more significant in those cases (Gotham *et al.*, 2018; Griffin *et al.*, 1999). This contradiction likely results from other differences in the surveyed population that may be discovered through analysis. The nature of the survey as an online questionnaire caused some innate bias toward individuals of higher education levels, which was considered in the post-stratification weighting of the survey responses (Evans & Mathur, 2005). Finally, political affiliation was measured on a three-point scale (Democrat = 1, Independent = 2, Republican = 3). Political affiliation is an important factor when considering natural hazards related to climate change because of the politicization of climate change (Shao *et al.*, 2014) and related hazards such as hurricanes (Shao *et al.*, 2017a) and sea level rise (Shao *et al.*, 2020) in the United States. Generally, Republicans are less likely than Democrats to consider the immediate and physical effects of climate change to be a significant concern, which can lead to an underestimation of the extent and severity of hazards, such as hurricanes and floods, that are generally mentioned alongside climate change (Shao & Goidel, 2016; Zaharan *et al.*, 2008).

The second set of independent variables considered for data analysis was the knowledge and opinions about coastal hazards and related mitigation specific to the New Orleans metropolitan area. First, respondents were asked to rate their level of knowledge regarding the threat posed by coastal hazards on a scale from 1 (“not informed”) to 4 (“very informed”). This information provided a self-reported level of confidence with the perceptions of risk and opinions regarding hazard mitigation explored in other parts of the survey (Shao *et al.*, 2020). Next, the respondents’ attitudes toward changes in natural hazards were measured. Respondents were presented 5 factors (number of hurricanes, strength of hurricanes, number of floods, level

of coastal water, and amount of rainfall) and were asked to determine whether, in their opinion, that particular hazard had increased, decreased, or stayed the same within the past 30 years.

These questions were coded in logical order for data analysis (decreased = 1, stayed the same = 2, increased = 3). These questions identified the coastal hazards that the respondents believe have intensified in recent decades, and are therefore those hazards that they believe will be points of significant concern in the future, which allows policymakers to identify where their focus should be allocated in terms of hazards that threaten the region when planning preventive mitigation (Shao *et al.*, 2020). Next, respondents were asked to identify whether or not they had personally experienced a hurricane event in the past 10 years. This question was coded as a binary variable for data analysis (1 = Yes, 0 = No). This question allows the support of mitigation projects, many of which mitigate against hurricane events, to be tested against whether or not an individual was impacted by a recent hurricane event.

Next, respondents were asked whether or not they owned flood insurance, which was coded as a binary variable for data analysis (1 = Yes, 0 = No). This, along with a follow-up question that determines the reason for flood ownership, provided a record of whether or not an individual resides within the designated 100-year flood risk zone, as residents within this high-risk zone are required to purchase flood insurance (Shao *et al.*, 2017b). Homeownership was utilized as a dummy variable for this factor, characterized by individuals who own homes (1 = Own, 0 = Other) and individuals who rent homes (1 = Rent, 0 = Other). The use of homeownership as a dummy variable assisted in explaining flood insurance ownership, as individuals who own homes rather than rent are more likely to voluntarily purchase flood insurance (Shao *et al.*, 2017b). To determine trends of individuals taking physical actions to improve personal resilience, respondents were asked to identify each of 8 different resiliency

projects, such as the purchase of sandbags or a backup generator, that they have personally undertaken for their household or property. For data analysis, the total number of actions taken was determined and used as a continuous scale to identify individual willingness to take actions to protect themselves. This also provides a scale to identify the impact of the moral hazard issue, which predicts a negative correlation between personal mitigation actions and support for governmental implementation of similar mitigation actions. The variable created for statistical analysis ranged from 0 (no action) to 9 (all available actions).

The self-reported individual confidence in the current disaster relief plan was recorded as a Likert scale question, with responses ranging from 1 (“not at all confident”) to 5 (“very confident”). This question established the stance that the individual takes regarding the municipal disaster relief plan and suggests an increased or decreased degree of urgency in the policy changes tested for in the dependent variables (Flannery *et al.*, 2015; Frazier *et al.*, 2010). Finally, respondents were asked whether or not they believe that the local government is currently capable of handling a major flood event. Responses were coded in increasing confidence in the government’s capability (No = 0, Maybe = 1, Yes = 2). This trust in the capability of the local government is correlated to the purchasing of flood insurance in addition to the support of government projects and initiatives since individuals are less likely to support resources from taxes being used for projects and initiatives that the individual doesn’t believe will cause any significant benefit to them or the community (Shao & Goidel, 2016).

Dependent variables

The dependent variables for this project were selected to be those which identified the New Orleans residents’ opinions as to which hazard mitigation focuses should be prioritized by the local government in the interest of protecting against the potential damage caused by extreme

coastal hazard events. The first set of questions presented seven mitigation actions that are currently employed by the local government in response to the risk posed by coastal hazards (levee development, coastline restoration, emergency education, the flood warning system, the flood drainage system, property relocation out of high-risk areas, and incentives for property fortification projects). Respondents were asked to determine, for each factor, whether or not they believed that the prioritization of that factor was important, on a scale from 1 (“not important”) to 4 (“extremely important”) with no “neutral” option. Upon descriptive analysis of these seven questions, it was decided to run factor analysis to determine the latent factors. This allowed the questions, through the aggregated topics they represent, to be applied in a more meaningful way to the existing and future policy managed by the local government. For example, it is more difficult to apply public opinion of proposed property relocation to the entire approach to public policy by the municipality than it is to apply public sentiment of projects similar to property relocation. With this in mind, three-factor analysis was run on this set of questions using R, which was supported by a failure to reject the null hypothesis to the idea that more or less than three factors would provide more significant results ($p = 0.118$).

Table 2

Factor analysis for the dependent variables identifying support of municipal projects. These variables were found to be loaded on three factors: structural projects, non-structural projects, and incentive-based projects.

Variable	Structural Projects	Non-Structural Projects	Incentive Projects
Levee System Development	0.714	0.257	0.316
Coastline/ Wetland Restoration	0.678	0.240	0.167
Emergency Education	0.336	0.651	0.187
Flood Warning System	0.418	0.838	0.132
Flood Drainage System	0.884	0.307	0.117
Relocation of High-Risk Structures	0.117	0.570	0.421
Incentives for Private Resilience Projects	0.297	0.255	0.910
Factor Eigenvalue	2.141	1.733	1.213
Cronbach's Alpha	0.79	0.76	N/A

Factor Analysis

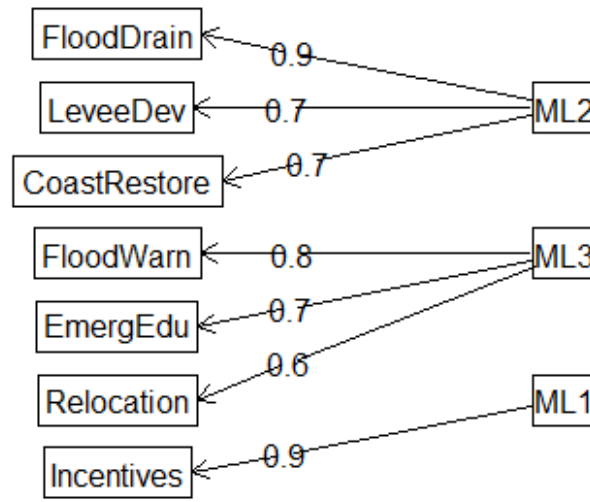


Figure 6. Visualization of the factor development process in R using varimax rotation. The included values represent factor loading values on each of the three factors. Upon completion, factor ML2 was designated “Structural Projects” and factor ML3 was designated “Non-Structural Projects”. Factor ML1 was not changed from the variable “Incentives” since only that variable was found to be loaded on factor ML1.

Upon the completion of factor analysis, three categories were established for the survey questions to identify trends based on the issues and functions associated with the underlying variables combined under each factor (Table 2; Fig. 6; (Joshi *et al.*, 2015)). First, questions relating to physical construction and infrastructure projects (levee development, coastline restoration, and the flood drainage system) were grouped as the first factor, designated “structural projects”. Second, questions relating to programs benefiting the individuals of the metropolitan area directly (emergency education, the flood warning system, and high-risk property relocation) were grouped as the second factor, designated “non-structural projects”. Finally, the question relating to increased incentives for personal fortification projects was left on its own, since it was the only question to address the incentivization of individual projects rather than the undertaking of municipal-scale projects by the local government itself. Upon creation, a

test of Cronbach's alpha was applied to both of the established factors on which multiple variables were loaded. The first factor, structural projects, returned a Cronbach's alpha and a standardized alpha value of 0.79. The second factor, non-structural projects, returned a Cronbach's alpha and a standardized alpha value of 0.76. When combined with the fact that the eigenvalues for all three factors were greater than one, it was indicated that the results of the factor analysis are reliable and that the variables considered by each factor are consistently related within the context of the factor (Wang, 2009). Using the additive scaled variables method, the Likert scale questions loaded on each factor were summed for each respondent, which created a new scale that identifies overall support of the general mitigation strategy identified by the factor itself. This created ordinal variables that were subsequently used for inferential statistical analysis.

The other question utilized as a dependent variable asked respondents how involved they expected the city of New Orleans to be in the prevention of flood damage to their property. Responses were coded on a scale from 1 ("not involved") to 5 ("very involved"). Laypeople have generally be shown to be largely unaware as to the status of their property in terms of location within disaster risk zones, which is in part explained by insufficient communication of information by municipalities and by the lack of power felt by individuals to protect against large-scale threats, which dissuades them to attempt to find detailed information about the threat in the context of their property (Arlikatti *et al.*, 2006). Because of this, many individuals believe the responsibility of protection of the region in the face of large-scale threats to be placed in the hands of the municipality rather than the individual, which increases their expectation of the effort that the municipality places into hazard mitigation.

Upon sorting and coding the data, the respondents' answers to the survey questions were applied probability weights created through raking. Probability weights were elected to be applied as a post-stratification method since the survey, being distributed online, exhibited bias in certain demographic factors (Evans & Mathur, 2005). This method of post-stratification considers these probabilities and corrects values and trends accordingly during survey analysis (Zhang, 2000). These weights were created using values related to age, gender, race, education, and party affiliation for the population and were applied to values for these factors present in the populations of Jefferson, Orleans, and St. Tammany Parishes.

Regression models

Inferential analysis was conducted using R. Because both the survey questions and calculated factors utilized as dependent variables are ordered on an ordinal scale, the method chosen for analysis was an ordinal logistical regression model using the "svyolr" function within the "survey" package in R, which designates a model as an ordinal logistical regression equation assuming probability weights. Four models were created in total to represent expected municipal involvement in preventing flood damage, support of structural projects, support of non-structural projects, and support of incentives related to private coastal hazard mitigation. For these models, demographic factors (age, gender, race, education, and political affiliation), interpretation of the recent change in coastal hazards (number and strength of hurricanes, number of floods, water level, and rainfall), homeownership, insurance ownership, number of personal mitigation measures, experience with recent hurricane events, self-reported knowledge of climate change, expected priority of climate change policy, expected immediacy of climate change policy, confidence in the municipal hazard mitigation plan, and trust in the government's capability of flood mitigation were considered as independent variables. The survey weights calculated from

observed demographic factors were applied in each model during the survey design step of model creation in R.

Policy Analysis

To analyze the government coverage of coastal hazards in the New Orleans metropolitan area, the policy enacted by the local and state governments were considered. To identify the state approach, plans drafted by the Louisiana state government were identified from the Office of Homeland Security and Emergency Preparedness (OHSEP) and the Coastal Protection and Restoration Authority (CPRA), both of which operated at the request of the state government to produce hazard plans for the state. Plans from Jefferson Parish, Orleans Parish, and St. Tammany Parish were also analyzed. The policy documents that were focused on were the comprehensive master plans and hazard mitigation plans from each of these jurisdictions, in which particular emphasis was placed on the parts of each plan that addressed the threat or mitigation of coastal extreme hazards. The comprehensive master plans for the different levels of government and management cover all aspects of general land and communal development, which resulted in much of each plan only being considered as a model for the approach to planning by the municipality.

The emphasis in the analysis was placed on the hazard identification and mitigation sections of the plans, which approached the issue of New Orleans' notably elevated social vulnerability in a very general sense, but in one that accounts for all aspects of planning for the municipality as a whole (Emrich & Cutter, 2011). Further details about specific hazard mitigation actions and projects were collected from each municipality's hazard mitigation plan, which addressed the issue with a much narrower scope, being concerned primarily with social vulnerability and determining how vulnerability may be minimized and how protective measures

may be enhanced to be most efficient in protecting the residents of the state or local jurisdiction, in some cases focusing on individual communities within the parish (Cutter & Emrich, 2006). The general approach of each parish to the threat posed by climate change is also covered, although most policy has yet to implement large-scale mitigation against climate change impacts yet.

For each plan, the analysis of community risk and resilience, focus of mitigation initiatives, and breakdown of mitigation activities were all considered. Many of the plans provide their explanation of the social and economic vulnerability for the particular jurisdiction covered in the plan, which explains both the human and material assets present in the jurisdiction as well as the general threat posed to those assets by natural hazards. The general mitigation strategies considered by the municipality are described, and the benefits and drawbacks of each are described in the context of the municipality itself, taking both current conditions and past hazard experience into account and balancing hazard resiliency with continued economic and structural growth of the parish (Frazier *et al.*, 2010). Finally, the breakdown of all adopted actions is provided for each municipality, which can be used to identify the exact strategy toward preemptive and adaptive hazard mitigation for the region. This breakdown, provided in each jurisdiction's hazard mitigation plan, also assigns priority values to each action. Differences in the priorities of hazard mitigation actions undoubtedly exist between state and local governments and between parish jurisdictions, since the groups and individuals responsible for each plan prioritize different issues, which stem from community factors and natural factors within their jurisdictions (Flannery *et al.*, 2015). Upon combining these factors, the general approach to hazard mitigation in addition to the specific threats and methods of implementation that are

prioritized by the municipalities were identified and compared to those threats and mitigation measures that are most prioritized by the general public.

RESULTS

Survey Analysis Results

To address the position toward coastal hazards within the resident population within the results of the survey, the level of knowledge and involvement with these hazards and hazard mitigation was measured by questions included in the survey. The information included in these questions is self-reported by the individual. When aggregated, they provide a general idea as to the approach to hazard mitigation utilized by these individuals. In addition, noting the number of resilience actions adopted by individuals, regardless of what specific actions they are, provides an idea as to the manifested urgency of self-resilience and allows for an overall assessment of how seriously residents take their household vulnerability.

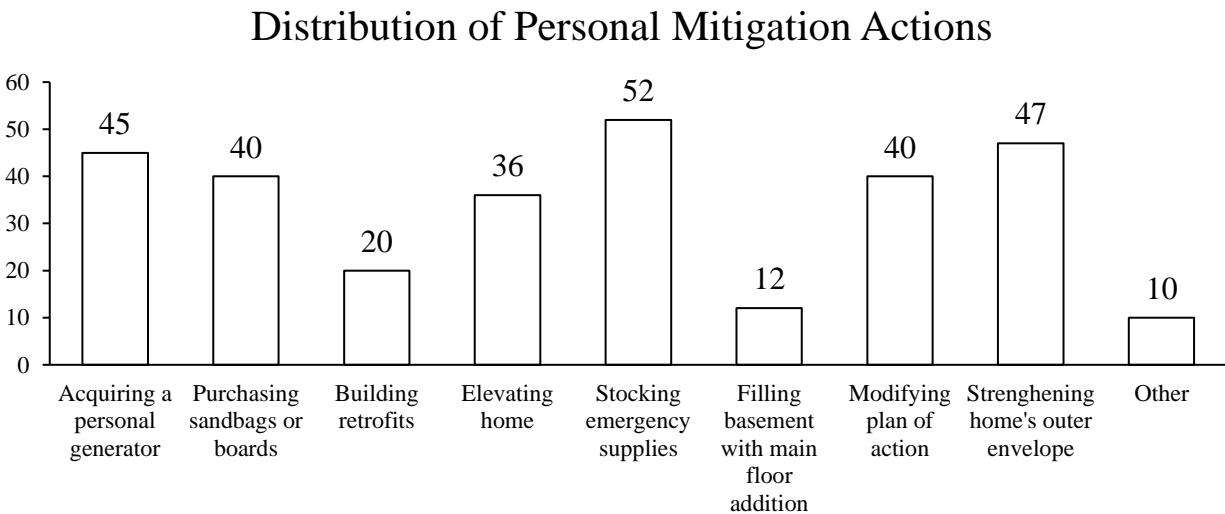


Figure 7. *The number of times each mitigation action was reported to have been adopted by individuals in the survey.*

Interestingly, it was discovered that the number of respondents who have personally taken measures to make their homes more resilient toward natural hazards is close to that of those who had not taken these measures. Of the respondents within the survey area, 218 said that they had taken resilience measures while 228 said that they had not. Respondents who claimed to have taken resilience actions were asked to select specific actions that they had taken (Fig. 7). The relatively broad spread of mitigation actions adopted by individuals suggests one of two trends. First, it is possible that the local government does not actively urge residents to take these actions. It is also possible that residents only took those actions that are necessary for their specific property to cover any potential weaknesses in their home. Increased adoption of these measures by residents is important, as they operate on a scale small enough to be inefficient for the municipality to become involved without the use of incentive programs. Another vital personal resiliency action in coastal areas is the ownership of flood insurance. Only 45% of the population currently owns flood insurance, with 55% remaining uninsured. In the metropolitan area of New Orleans, new homeowners and those who rent properties are required to own flood insurance if they live within the FEMA Special Flood Hazard Zone. However, other residents are not required to own insurance, which increases pressure on the municipality to incentivize insurance ownership to maximize the overall resiliency of the region.

The effects of climate change are generally linked to an expected increase in the frequency of coastal extreme weather events, such as hurricanes, as well the level of coastal waters. For a community such as New Orleans that already exhibits high social vulnerability to current coastal hazards, residents need to be aware of the effects that climate change will have on their community. Of the population of the New Orleans metropolitan area, the majority (68%) are at least somewhat well-informed about climate change (Fig. 8). Further, the majority of the

(74%) are concerned with the future effects of climate change. This is supported by past projects, which have established that Americans generally demonstrate a significant awareness of climate change and concern about the risks associated with it (Leiserowitz *et al.*, 2019)

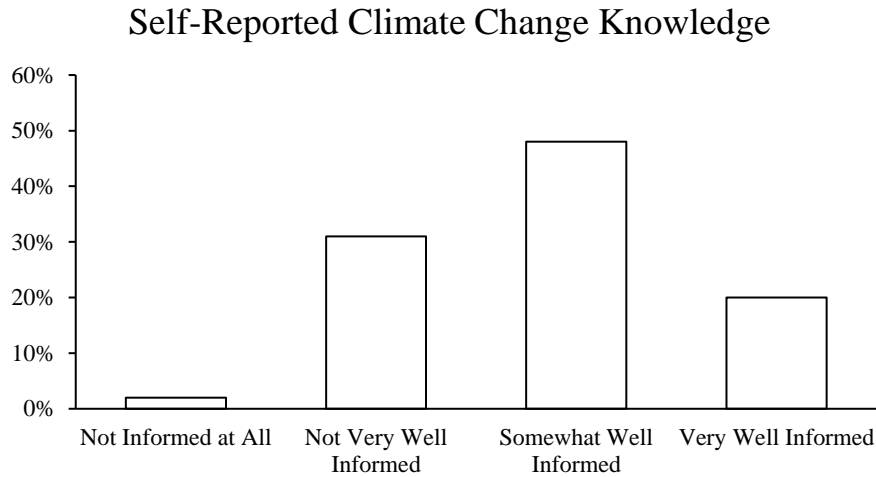


Figure 8. *Reported knowledge of the causes and effects of climate change by individuals in the survey*

Sea level rise is one of the most impactful effects of climate change on coastal communities. Rising sea levels can result in ocean water covering low-altitude land, which forces individuals to leave these areas as the water rises or the threat of imminent water level rise continues to increase. As the level of coastal water increases, the risk of flooding from hurricane events becomes elevated because of the erosional effect that sea level rise has on barrier islands and wetland systems (Costanza *et al.*, 2008), the latter of which is prominent in the Louisiana coastline only 100 miles southeast from the city proper of New Orleans. Because of these factors, layperson perception of the future of the level of the water off the coast of Louisiana was recorded in the survey. The majority of the population (81%) believed that, in the near future, the level of coastal water will increase. Residents of New Orleans are, in general, aware not only of the presence of climate change as a concept and as a process, but also of its direct future ramifications on their community.

Although sea level rise is one of the more frequently mentioned effects of climate change, there are several other effects that the public generally associates with climate change (Emrich & Cutter, 2011). Some of these effects are identified as coastal hazards, such as hurricanes and floods caused by storm surge and excessive rainfall. Because laypeople generally associate these factors with climate change, examining their perceptions of these hazards helps to identify which aspects of hazard amplification individuals are most concerned about. It also helps to identify the specific hazards that are perceived by the public to pose the greatest immediate and long-term threat to the region.

Percieved Increase in Various Coastal Hazards (Past 30 Years)

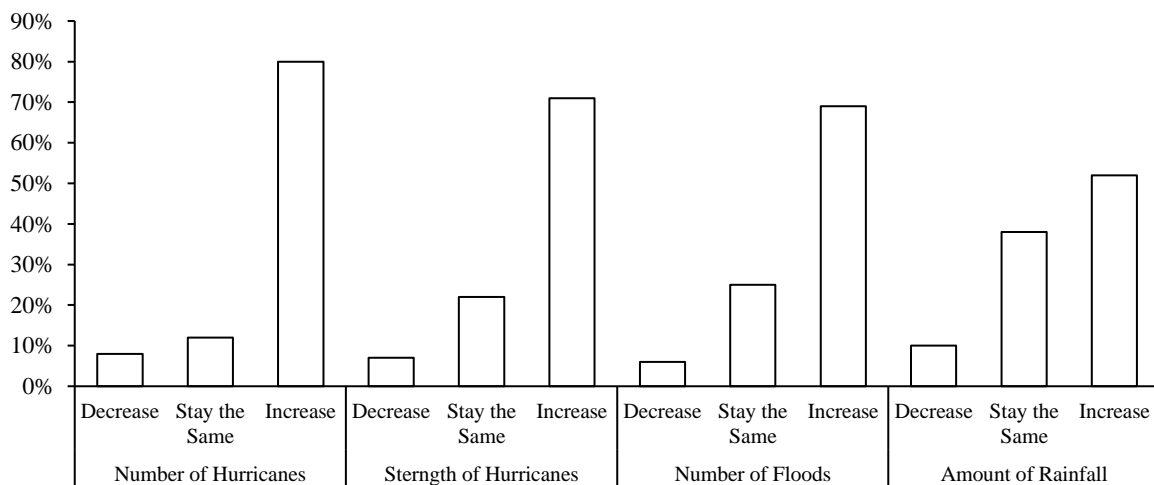


Figure 9. The number of individuals who report that they believe that certain coastal hazards have increased over the past 30 years. The results indicate that, despite not being directly connected to the effects of climate change, these impacts are generally being perceived by laypeople to be increasing.

The respondents of the survey generally believe that the number of hurricanes, the strength of hurricanes, the number of floods, and the total amount of rainfall have increased over the past 30 years in the New Orleans metropolitan area. This effect is most pronounced when addressing hurricanes, as 80% of the population believes that the number of hurricanes has increased and 71% believe that the strength of hurricanes has increased. This is understandable

given the experience that the residents of New Orleans have had with major hurricanes since 2005 and as recently as 2020. This indicates that hurricanes may continue to amplify in the future and continue to be a significant source of worry for residents. Flooding, considered by scientists to be the most significant natural hazard to New Orleans, specifically those communities located below sea level, is also shown to be a point of concern with respondents. 69% of the population believes that the number of floods to have increased within the past 30 years. This suggests that, despite the significant focus on flood mitigation by local and regional authorities, the mitigation of flood risk should continue to be a major point of attention when considering the safety of communities within the region. Finally, 52% of the population that rainfall has increased over the past 30 years, with 38% believing that there has been no noticeable change within that period. Despite rainfall being a source of attention for mitigation, since drainage systems are required to prevent communities below sea level from flooding even during regular events, rainfall is not generally perceived to be a threat that is increasing.

When asked about the local government's expected involvement in climate change mitigation, individuals generally responded that they believed that the government should be involved in preventative measures regarding the prevention and reduction of hazards related to climate change. 66% of the population believes that the local government should be involved in this process. In addition, respondents reacted positively to the idea that the local government should implement projects for future impacts of climate change in its current planning process. 77% of the population of New Orleans agrees with this statement. This is interesting, as research into public perception of the immediate threat of climate change indicates that the majority of Americans do not believe that climate change poses an immediate threat, but rather will pose a threat in the future (Leiserowitz *et al.*, 2019; Ratter *et al.*, 2012). This suggests that individuals in

the New Orleans metropolitan area possess foresight about the threat posed by climate change to their community in the future and believe that it is the responsibility of the local government to protect them from those hazards in the future. This is best achieved by beginning the planning and mitigation process as early as possible to ensure that emergency plans and critical infrastructure are capable of dealing with the potentially catastrophic consequences of climate change. The holding of this belief by the general public is contrary to issues faced in the communication of the threat of climate change in many regions in America, often complicated by the abstract nature of the issue and the delayed gratification of mitigation. This serves as a testament to the quality and urgency of public hazard communication by the New Orleans government and private interest groups (Moser, 2010).

Aggregated Individual Support for Mitigation Projects

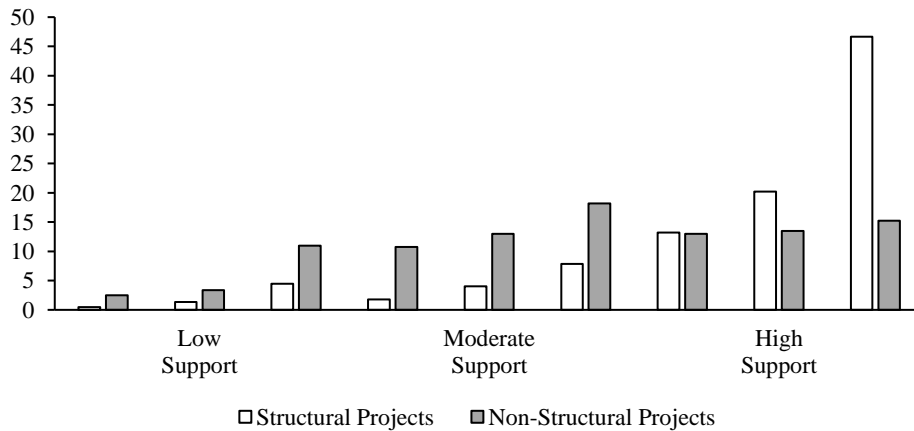


Figure 10. *Percentage of individuals that prioritize structural and non-structural mitigation projects. Priority is measured on a scale of 1-9 for structural and non-structural projects.*

The trend of structural and non-structural mitigation project support among respondents generally follows that established by the support of climate change initiatives. As residents perceive that the current coastal hazards that pose a threat to their community increase in magnitude, their support of policy and programs that would mitigate these threats also increase.

In general, support of structural projects was stronger than the support of non-structural projects, although both exhibited noticeable trends toward high-level support rather than low-level support. This is likely in part caused by the influence of political ideology in the support of non-structural projects, which may influence Republicans who otherwise support structural projects to withhold support of non-structural projects (Table 3). In either case, the distribution of reported priority for these mitigation methods reinforces the idea that residents of the New Orleans metropolitan area are highly aware of the risks that pose a threat to them and place the responsibility for necessary mitigation on their local government.

79% of the population believes that incentive programs should be a priority in some way in the planning approach to hazard mitigation, although no differentiation was made between different incentives. This trend could change depending on the popularity of the incentivized mitigation action and how successful implementation of these actions is to the development of resiliency within New Orleans. Because individuals who have already taken personal mitigation actions are less likely to support the government incentivizing or addressing these actions, this trend should be explored in more detail in a future study (Husted & Nickerson, 2019).

Confidence in Municipal Hazard Mitigation Plan

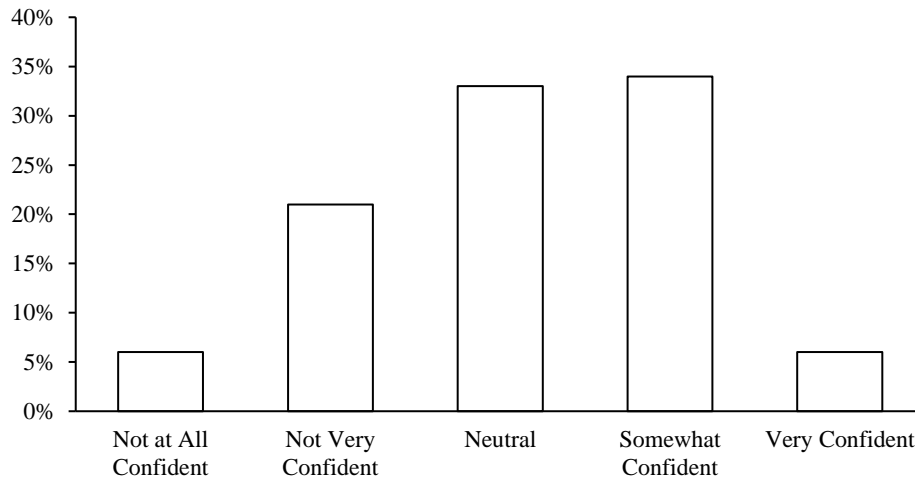


Figure 11. General reported resident confidence in the ability of their parish hazard mitigation plan. In this case, no specific hazard was focused on, but rather the capability of the plan as a whole.

Finally, respondents answered questions to determine their current perception of municipal action both in terms of adaptive and preventive measures relating to coastal hazards, particularly in terms of the anticipated response to major flood events. Respondents had somewhat mixed opinions about their confidence in the capability of the current hazard mitigation plan. A considerable percent of the population expresses both confidence (39%) and lack of confidence (27%) in the plan, with 33% of the population undecided about their impression of the capability of the plan (Fig. 11). This relatively high rate of indecisiveness may either indicate apathy or lack of information about their respective hazard mitigation plan, neither of which is productive for planners tasked with protecting the municipality (Flannery *et al.*, 2015). When determining the effectiveness of the government’s preventive measures to handle flood events, residents are even less positive, with only 23% of the population confident in the government’s ability to handle a future major flood event. Further, 47% express a negative perception of the capability of the municipality. Of the population that expresses doubt of the

government's plan of action, the majority (80%) attribute their doubt to the capability of the flood drainage system. The drainage system is critical in limiting floodwaters in the parts of New Orleans that lie below sea level. This is particularly interesting because it identifies a major issue for which the general public doubts the ability of the municipality to address in its policymaking and planning processes. When combined with the impressions of the survey population on the threat posed by coastal hazards and their impressions and support of policy initiatives within the municipality, it becomes clear what the municipality should focus on in its planning and policymaking processes to alleviate the worries and concerns of its residents. The question, therefore, becomes whether or not this objective is indeed being accomplished in the current approach to policy and planning employed by the parish governments within the New Orleans metropolitan area.

Table 3*Results of ordinal logistical regression models.*

Variable	Expected Flood Involvement		Support of Structural Projects		Support of Non-Structural Projects		Support of Incentive Projects	
	b	t	b	t	b	t	b	t
Demographics								
Age	-0.30	-2.29	0.23	1.52	-0.04	-0.35	0.09	0.73
Gender (Male)	-0.00	-0.01	0.09	0.33	0.07	0.25	0.14	0.52
Race (White)	-0.13	-0.47	0.09	0.25	-0.53	-1.62	-0.49	-1.65
Education	-0.11	-1.44	0.16	1.68	0.10	1.20	0.14	1.36
Political Ideology	-0.00	-0.01	-0.32	-1.85	-0.20	-1.10	-0.30	-1.58
Hazard Perception								
Knowledge about Climate Change	-0.13	-0.68	-0.11	-0.48	-0.19	-0.85	0.01	0.02
Number of Hurricanes	-0.19	-0.61	-0.57	-1.66	-0.59	-1.79	-0.38	-1.01
Strength of Hurricanes	0.27	1.01	0.20	0.71	0.10	0.44	-0.47	-1.41
Number of Flood Events	0.14	0.61	0.11	0.47	-0.13	-0.68	-0.00	-0.01
Sea Level	-0.21	-0.86	-0.08	-0.35	0.16	0.67	0.27	1.05
Amount of Rainfall	-0.08	-0.44	0.12	0.52	0.26	1.41	-0.10	-0.55
Flood Experience	0.07	0.36	-0.07	-0.32	0.04	0.21	-0.16	-0.62
Personal Resilience								
Homeownership	0.15	0.54	0.03	0.11	0.67	2.23	0.96	2.80
Insurance Ownership	-0.01	-0.02	0.29	0.99	-0.34	-1.33	-0.68	-1.82
Resilience Adoption	2.72	3.31	0.18	0.29	-3.63	-5.43	1.54	2.58
Policy Perception								
Urgency of CC	0.18	1.07	0.61	3.73	0.52	2.73	0.50	3.17
Expected CC Action	0.93	5.75	0.19	1.48	0.34	2.42	0.21	1.57
Confidence in HMP	0.43	2.72	-0.14	-0.97	0.12	0.85	0.11	0.82
Trust Gov Protection	-0.01	-0.05	-0.19	-0.67	-0.16	-0.62	-0.38	-1.45
Pseudo R-squared								
N	0.12		0.06		0.06		0.06	
	446		446		446		446	

The results of the ordinal logistical regression models are detailed in Table 3. Not surprisingly, the expectation of the local government to prevent flood damage is positively correlated with confidence in the current local hazard mitigation plan. Individuals who believe that the government is capable of mitigating and adapting to extreme events expect that the government applies this ability in the event of an extreme event. This likely suggests that the citizens are confident with the government's handling of the threat posed by coastal hazards, which would indicate that communication between the government and individuals in the coverage of issues that residents are concerned about is strong (Birkland, 2001). In addition, the expectation of the government to address climate change is positively correlated to the expectation of the government to mitigate coastal hazards. It is likely in the best interest of parish governments in the New Orleans metropolitan area to address the threat of coastal hazards and climate change hazards in tandem, as residents consider the two to be generally related and therefore should be approached with similar efforts and magnitudes in the policymaking and planning processes. In addition, resiliency project adoption is positively correlated with expected flood involvement. This likely indicates that individuals who are vigilant of coastal hazards enough to mitigate against them on a small scale believe that the municipality should be responsible for the mitigation of these hazards on a larger scale. Finally, age is negatively correlated with the expectation of government involvement, which has been explained as increased concern about climate change and related risks (Shao *et al.*, 2017c). The application of climate change trends to perceptions of coastal hazards suggests that general levels of concern in terms of threats that are assumed to be connected or at least insinuated to be connected by social factors are similar (Griffin *et al.*, 1999).

Between the two variables determining support for mitigation projects, relatively similar trends were observed, although more correlations were identified between support of non-structural projects and the independent variables. Support of non-structural projects was found to be negatively correlated with the intensity of adoption of personal mitigation efforts and projects. This is consistent with the moral hazard argument, as it suggests that individuals who have already acted by themselves are hesitant to support government initiatives and projects that would incentivize or lead projects to implement those actions (Husted & Nickerson, 2019). Because of this trend, it is believed that, contrary to initial belief, those individuals who are most cognizant of the threat are less likely to support mitigation efforts that operate on smaller scales. However, it was discovered that support of homeownership is positively correlated with support for non-structural projects. This suggests that individuals who own properties are generally more likely to support efforts to improve non-structural large-scale mitigation, regardless of whether or not they have addressed small-scale mitigation themselves.

It appears that individuals already in support of major policy are likely to support smaller-scale mitigation efforts. Support of structural and non-structural coastal hazard mitigation projects is shown to be positively correlated with the belief that policy regarding the mitigation of climate change risks should be adopted to the municipal planning process now. This is ultimately counterintuitive to the level of protection offered by the government, as it potentially results in fewer projects that the region desperately requires being explored in the latter stages of planning and being implemented within the jurisdiction of the municipality. Because of this, planners may not want to primarily appeal to individuals who generally support large-scale projects, since analysis supports that they already are in support of these initiatives. Rather, public outreach should target individuals who are already in support of the idea behind

these projects, such as structure elevation, because those individuals are less likely to support governmental action regarding these projects.

As with support of structural and non-structural projects, support of incentives for personal mitigation actions was found to be positively correlated with a feeling of immediacy for the implementation of climate change initiatives. This is likely true for the same reasons that this correlation was observed for the support of structural and non-structural projects by residents. One notable variable that was not observed to be significantly correlated to support of incentive programs is those of insurance ownership. The moral hazard argument suggests that the adoption of personal mitigation efforts would be correlated to incentive projects as it is with structural and non-structural projects, so the finding that it isn't correlated to incentive projects is surprising (Husted & Nickerson, 2019). However, it was found that homeownership and adoption of resilience measures were both positively correlated with support of incentive projects. One explanation for this is that, while insurance is a monetary incentive that only benefits a property owner after a devastating event, resilience measures actively protect properties before an event occurs. Because of this, homeowners are more likely to support the incentivization of preemptive small-scale resiliency projects rather than adaptive insurance coverage. The homeowner would face less grief if they invested in mitigation before a hazard and protected their property rather than being reimbursed for their property after it has been destroyed by an extreme event.

Interestingly, political ideology was not found to be significantly predictive of support or expectations of any of the tested dependent variables. This is contrary to the results of past studies, which have generally identified Democrats to be more supportive of hazard and climate change mitigation projects and efforts than individuals that are Republicans (Shao *et al.*, 2020; Zaharan *et al.*, 2008). This observation may be explained by the location of the study in the city

of New Orleans. The looming threat of coastal hazards is significant to the city because of its history with extreme events and because of its elevated social vulnerability. This is likely a factor that is emphasized by the parishes in the metropolitan area in communication with its residents to maximize their resilience (Cai *et al.*, 2016; Cutter & Emrich, 2006). Because of this, support of hazard mitigation in the case of an especially vulnerable community such as New Orleans may be more related to perceived risk than a variable such as political ideology.

Policy Analysis Results

In addition to results from the survey conducted among residents of the New Orleans metropolitan area, the results of the analysis of parish policies and plans were also considered to determine the relationship between the municipality and its constituents. Because the city of New Orleans shares its boundaries and municipal governance with Orleans Parish, the city government is in charge of the development and implementation of the comprehensive master plan for its residents. The Orleans Parish comprehensive master plan is divided into four major parts. First, the parish aims to work with other governmental organizations and the private sector to develop an implementation strategy of mitigation efforts that strengthens the parish's capability to provide flood protection without sacrificing community or industry development. Next, a plan for water management, focusing specifically on stormwater, is outlined to combine the ecological and conservation benefits of green infrastructure with stormwater management. Because of the necessity of proper stormwater drainage resulting from the location of the parish below sea level, several projects are planned for this specific purpose that encompass different public and private entities within the parish.

Significant emphasis is placed on developing the capability of the population of Orleans Parish to be able to adapt and prepare for major natural events. This is accomplished both

through the incentivization of personal resilience measures that help to reduce household risk in addition to the promotion of education and outreach programs to ensure that the public is knowledgeable about the threats that they will have to face in the future. Finally, a detailed plan for disaster preparation is outlined, which pays specific attention to the improvement of critical infrastructure and the preparedness of home and property owners in the parish. By developing the resilience and preparedness of the parish at both the individual and municipal levels, the parish will be more capable of managing the stress of an extreme event. The parish acknowledges that despite efforts, the risks posed by tropical cyclones and storm surge are especially high and still account for a significant amount of the perceived risk by individuals and by government officials. This results in these hazards being at the top of the list of priorities for active and future projects within the parish.

When compared to the comprehensive master plan from Orleans Parish, the Jefferson Parish comprehensive master plan places a larger emphasis on the physical strengthening of the parish's infrastructure and public developments than on the preparation of residents and alleviating of social vulnerability. Jefferson Parish employs four major topics of interest to its master plan, with four of these topics relating primarily to efforts handled specifically by the municipality. First, preventive measures are detailed to reduce future damage from hazards. These measures include the application of structural advancements and studies to determine the risk to plan action items most efficiently. Next, the plan identifies public mitigation methods to reduce social vulnerability, primarily through the promotion of investment in personal mitigation methods and public education programs. Structural and construction mitigation items are also explored to reduce the effects of potential natural hazard impacts. This is attained through the development and intensification of building code and ordinance enforcement, especially when

addressing structural development and reinforcement. Finally, the plan establishes programs to strengthen the structural environment of the parish, which mostly deals with projects aimed at establishing green infrastructure and restoring damaged coastal wetlands and the coastline in the south section of the parish. The calculated risk and severity of specific coastal hazards, in particular floods and hurricanes, are similar to that of Orleans Parish. This makes sense, as the topographical profile of Jefferson is very similar to Orleans, with the only real observable difference being the southern extent of the parish which extends south to the Gulf of Mexico, which results in an increased emphasis on the more immediate mitigation of coastal erosion and sea level rise hazards.

The comprehensive master plan adopted by St. Tammany Parish takes an approach similar to that of Orleans and Jefferson Parishes. The parish recognizes that the most significant natural threats to the population are major flood and tropical cyclone events, and mitigation efforts generally focus on these major threats. The location of St. Tammany north of Lake Pontchartrain and away from the Mississippi River allows the parish to not worry about the issues faced by Orleans and Jefferson as a result of them being located below sea level, most notably the maintenance of the stormwater drainage system. However, the fortification and further development of the parish's levee system is nonetheless a high priority for the municipality. The wetland system that composes the parish's southern border with Lake Pontchartrain is fragile and vital to the ecosystem in the parish. During Hurricane Katrina, the wetland system was damaged and still has yet to fully recover, and St. Tammany Parish places a significant emphasis on the need to redevelop and strengthen these wetland systems. This is in part because the levee system which protects communities in the northern section of the parish is not practical in the southern section, which relies on the wetland system for protection against

severe flood conditions, much like southern Jefferson Parish relies on its coastal wetland system to protect them from storm surge during hurricane events. The parish also emphasizes the importance of the levee system where it is implemented. Storm surge is still a considerable concern, even with the existing levee and wetland buffer systems, so additional levee installations and improvements are considered to be a high priority for the parish as well. This emphasis is repeated in the hazard mitigation plan for the parish.

Table 4

The priority of hazard mitigation projects addressed in the municipal hazard mitigation plans for Jefferson, Orleans, and St. Tammany Parishes.

Project	Jefferson Parish	Orleans Parish	St. Tammany Parish
Improve construction standards and codes in high-risk areas	High	Medium	High
Fortify public and high-risk private properties	Medium	Medium	Medium
Improve drainage infrastructure in populated areas	High	High	Low
Strengthen or acquire high-risk/repetitive loss structures	High	Medium	Medium
Strengthen existing fluvial, coastal, and littoral levee systems	High	High	High
Restore protective coastal and littoral wetlands	High	Medium	High
Increase public preparedness for major hazard events	High	High	High
Strengthen emergency warning system for parish	High	High	High
Promote public hazard education initiatives	Medium	High	High
Increase information focus on non-conforming properties	Low	High	Low
Update sources of publicly available hazard data	High	High	High
Improve large-scale evacuation procedures	Medium	High	Medium
Incentivize individual relocation from high-risk areas	Low	Medium	Low
Incentivize private resilience projects for homeowners	Medium	High	Medium
Aid with small-scale private safety developments	Medium	High	High
Provide an avenue for aid for large-scale private safety developments	Medium	High	Medium
Pursue lower insurance premiums for at-risk property-owners	High	High	High
Encourage purchasing of household flood insurance	High	High	High

Analysis of the action items detailed in each parish's hazard mitigation plan mostly supports the trends observed in their respective comprehensive master plans (Table 4). Orleans Parish in particular allocates a surprising amount of their project priority to those targeted toward public mitigation and reduction of social vulnerability. Orleans places considerably more focus on incentive programs to encourage residents to explore and implement private mitigation actions but places less emphasis on the planning and implementation of structural projects. The priority of these projects remains elevated due to their overarching benefits in the overall pursuit of improving the vulnerability faced by New Orleans residents through mitigation. However, the priority granted to these projects is generally less than projects dealing with improving public resilience and incentivizing private resilience efforts. This may be because of the urban background of Orleans Parish. The smaller total land area and lower number of undeveloped areas in the parish result in less of a need to address neglected or undermanaged high-risk properties. This allows the parish to address individual high-risk properties on a smaller scale rather than in major initiatives detailed in the hazard mitigation plan. In addition, the higher population density observed in the large city results in a significant need for individuals to be prepared in the event of another disaster like Hurricane Katrina. This is because mistakes and slow response in vital areas stemming from the underprepared population and municipal leaders resulted in further issues after the storm had long since dissipated (Jonkman *et al.*, 2009). By focusing on these issues, Orleans can cater the hazard mitigation plan to suit its own needs as the principal population center of the metropolitan area.

In contrast, the approach to hazard mitigation projects by Jefferson Parish focuses more on structural mitigation rather than non-structural projects and incentives for private resilience mitigation. In some cases, such as with the approach to non-conforming properties and

incentivizing relocation from high-risk areas, the idea was mentioned as a potential avenue for action in the comprehensive plan or hazard mitigation plan but was not adopted to the action plan for the parish. However, this can somewhat be explained by the general approach to action items that Jefferson Parish took with its hazard mitigation plan. Unlike Orleans Parish, Jefferson includes a somewhat shorter list of specific items to adopt but tailors each of these items to each separate community within the spatially larger parish. Unlike Orleans, Jefferson has to consider the health of its wetlands and its coastline near the Gulf of Mexico, which are natural features not found in Orleans. By taking an approach more focused on specialized physical project implementation, Jefferson Parish can provide structural resilience more effectively to individual communities throughout the parish. It is worth noting that this trend of specialization within the shorter list of hazard items is only evident when viewing the list of action items in the hazard mitigation itself. This is a detail that, when compared against the seemingly more robust Orleans hazard mitigation plan, might be missed when viewed by a layperson.

As with Jefferson Parish, the hazard mitigation adopted by St. Tammany Parish is significantly less detailed than that used in Orleans Parish. This is likely because of the variation found in the topography and communities throughout the parish that requires diversification rather than specialization in planning. St. Tammany places a heavy emphasis on the continued development of the wetland and levee systems but allocates little emphasis to the floodwater drainage system. The overall distribution of hazard mitigation strategies of physical, public, and incentive-based projects is relatively even, with significant points of interest highlighted from each general category within the plan. In addition to the development of the wetland and levee systems, an emphasis is placed on making sure that new buildings adopt strict building safety codes and that old buildings be developed to ensure that they are up to code. The public outreach

programs outlined by the parish are detailed and emphasize the need for residents of the parish to be resilient within their households and be able to adapt properly during an extreme event. The parish assists individuals with smaller-scale resilience projects, although less of an emphasis is placed on larger projects and the incentivization of the process. Finally, ownership of flood insurance is required for all new homeowners and individuals renting properties. A major focus in the public outreach approach of the parish is therefore to encourage property owners that do not yet have insurance, possibly because they have owned their property for an extended time, to purchase flood insurance. This is because the communal ownership of flood insurance is the most efficient way for the parish to recover quickly after a major hurricane or flood event (The, 2009).

In the state of Louisiana, a significant emphasis is typically placed on the mitigation of damage caused by coastal hazards. The social and physical vulnerability of the New Orleans region of the state, in particular, is well-documented, so state and region-wide groups like the CPRA take these threats into account when developing regional policy and recommendations for municipal organizations (Coastal, 2017). In particular, the CPRA suggests widespread updates and upgrades to structural requirements and building codes on parish levels in addition to increased communication regarding these changes. This is particularly important when managing large-scale projects like drainage and levee developments with neighboring parishes so that cooperation can be utilized in the building of each parish's social resilience (Coastal, 2017). In addition, the CPRA calls for more incentive-based projects to be implemented, especially when dealing with private resilience efforts. Finally, the CPRA suggests that more aggressive public and private sector awareness and outreach programs be explored to better prepare individual residents for extreme coastal hazard events. In many ways, the municipal governments in

Jefferson, Orleans, and St. Tammany Parishes address these issues in their current approach to mitigation through their master and hazard mitigation plans for the parish, especially concerning physical, public, and incentive-based projects developed to increase the resiliency of the communities within the New Orleans metropolitan area.

Analysis of the comprehensive master plans and hazard mitigation plans of the three parishes revealed a notable omission of climate change policy in much of the policy adopted by all three parishes. In many of the documents for the plans, climate change is mentioned only a few times. In addition, when mentioned, the phrase “possible climate change effects” was often used to describe the threat posed by climate change (Jefferson, 2020). Climate change was mentioned as a factor used in the planning and policymaking processes in Orleans Parish, but few details were included as to what this involved. Although sea level rise is directly addressed in the plans of each of the parishes, the threat associated with rising sea levels is rarely attributed to or related to risks associated with climate change. Even when hazard mitigation strategies and projects consider changing future conditions, the general connotations of climate change to those specific projects are not explored in any significant way. The CPRA notes this general omission in its recommendations for parishes, citing a need to integrate information about future hazard conditions and consider climate change impacts as a direct factor in planning and policymaking decisions. Given the emphasis placed on governmental action and responsibility regarding climate change by residents in the survey population, this is a surprising trend. It identifies a clear case in which a worry shared by a majority of the population is insufficiently addressed directly and straightforwardly in the master and hazard mitigation plans of the parish.

DISCUSSION

Coverage of Current Hazards

In many ways, residents' risk perceptions and expectations of the resulting actions corresponded with the approach to hazard mitigation in the hazard plans for parishes within the New Orleans metropolitan area. Jefferson, Orleans, and St. Tammany Parishes all cite flood and hurricane events as those posing the greatest threat to the population, which is a sentiment shared by residents. The extensive history with hurricane events, flooding from rainfall events, and flooding from storm surge events has resulted in heightened concern for these events. Further, residents generally believe that the threat posed to them by these events is increasing with time as a result of changing environmental conditions. When considering resident perceptions of increasing number and intensity, the majority of the population believes that hurricane number and strength and number of floods has increased over the past 30 years. In addition, 51% of respondents reported having taken resiliency action against the threat of hurricanes and flood events to improve the safety of their lives and property under extreme conditions. Although results were generally mixed, most respondents reported being neutral or confident in the hazard mitigation plan of their respective parish. This indicates that a substantial percentage of the general public is at least content with the coverage offered in these plans.

In the parish plans, extensive background research and information are provided to justify the concentration of attention to certain approaches to mitigating hazards. All three parishes acknowledge flood and hurricane hazards to be the most threatening to the population, with

particular emphasis placed on recognizing the need for large-scale mitigation to account for the region's elevated social and physical vulnerability. The fact that the priorities outlined in the plans of Jefferson, Orleans, and St. Tammany Parishes match those held by residents not only emphasizes the comprehensive approach to the understanding of vulnerability in the population, but it also provides another case for the argument that the residents are highly aware of the risks associated with the hazards that they face as coastal residents. The awareness and the concern that comes from it is, in part due to the local governments' concentrated attention to detail in the research and development of the municipal plans in New Orleans. This attention to detail in the development of items that are expected to most effectively mitigate the vulnerability faced by the population of New Orleans is best exemplified in each parish's hazard mitigation plan. In these plans, the exact method of implementation of action items in response to major and minor hazards is detailed to allow for an understanding of what needs to be done to sufficiently protect the population. In addition, the focus of these details is varied to fit the profile of each parish and to provide hazard mitigation and relief most effectively where it is most needed. This demonstrates the degree to which residents' concerns are addressed and covered in the hazard plans.

Analysis of the logistical models based on the survey data reveals clear patterns in the support of municipal mitigation actions by residents. A positive correlation was identified between individual confidence in the parish hazard mitigation plan and an expectation of municipal flood involvement. Public confidence in their parish's hazard mitigation plan was found to be mixed, especially when considering flood events specifically, with the majority of individuals expressing doubt in the capability of the municipality to handle a major event. However, this may be explained in a few ways in the defense of the local government. First, the

comprehensive master and hazard mitigation plans have been adopted recently enough that some of the major projects detailed within them have yet to be fully implemented. When complete, these mitigation efforts are expected to contribute considerably to the resiliency of the metropolitan area. In addition, the scale of the approach by the municipalities may seem unconvincing at first glance but gain strength when observed in detail. The Orleans Parish hazard mitigation plan, for example, includes many different, highly detailed approaches for the entire parish in its list of action items (City, 2015). By contrast, the Jefferson Parish hazard mitigation plan includes a much shorter list of different items but includes specialized breakdowns by each community to detail the specific implementation of mitigation actions that are tailored to each community (Jefferson, 2020). If the context of the execution of the plan is not recognized, then the approach to mitigation by the parish may be underestimated by laypeople. This can lead to a decrease in confidence about the capability of the plan and the dedication of the municipality to mitigating current coastal hazards, even though significant actions are being taken to increase resiliency.

As a result, while the current actions implemented according to the parish's plans have yet to meet resident's expectations, the approach proposed in the plans suggests that effort is being actively expended to work toward sufficient mitigation. Specifically, residents are concerned about the capability of the flood drainage systems in Orleans and Jefferson Parishes and the protective levee and wetland systems in all three parishes. Of the structural projects detailed in the comprehensive master plans and hazard mitigation plans for the three parishes, these structural concerns are emphasized. They are recognized as those that not only require the most work to raise community resiliency, but also those that, when completed, will provide the region with the most significant increase in protective resiliency (Louisiana Coastal Master

Plan). The residents' concerns are being considered, and progress, albeit somewhat slow, is surely being made. However, because of the focus of municipal planning on the threat posed by current coastal hazards, the effects that climate change will have on the region are not covered in as much depth. This becomes a problem when the residents' expectations of local government involvement in climate change mitigation are considered.

Lack of Climate Change Mitigation

As it stands, the plans adopted by parishes in the New Orleans metropolitan area are generally successful in their coverage of the risks posed to residents by current coastal hazards. However, this finding notably does not necessarily extend to their coverage of the future risks of coastal hazards that are widely believed and predicted to increase in intensity as a result of climate change. The general approach to climate change mitigation by the local governments is to invest in projects that will ultimately provide structural and non-structural resilience against the increased risk caused by the increase in hazard intensity in the future. In part, this is effective, but it only really extends to mitigation items that apply specifically to risks associated with climate change that also have a considerable current impact. An example of this is coastal erosion, which is an issue now but will only intensify in the future from rising sea levels. By mitigating coastal erosion against rising sea levels, the municipality is indirectly implementing climate change mitigation into their plans without explicitly stating it. This is most likely done in the planning process to avoid unnecessary politicization of required mitigation efforts by associating them with climate change (Combest-Friedman *et al.*, 2012). If municipal plans and policies overuse the term "climate change", there will be a higher chance that projects will be met with pushback from individuals and organizations who are opposed to the implementation of climate change mitigation. To some people, the apparent political connotation of climate change

means that it would be improper to include it in city policies and plans. The avoidance of this language therefore succeeds in preventing the politicization of the planning process in terms of the potential association of climate change itself but comes with the drawback of weakening the stance of the municipality on the future effects of climate change (Leiserowitz, 2005).

When approaching municipal planning, it is important to consider input from all sources, as the three parishes in the New Orleans metropolitan area attest to the developmental process of their plans. It therefore should make sense for the municipality to essentially remain neutral on the scientific and social arguments for climate change to prevent this politicization of what should be an objective approach to hazard mitigation for the region (Leiserowitz *et al.*, 2019). According to the residents included in the survey sample, however, this is not the case. Through the survey distributed to the New Orleans metropolitan area, it was discovered that residents not only report being generally well informed about the threat posed by climate change but also that the majority of respondents are concerned with the potential effects of climate change in the near future. Respondents tended to believe that coastal hazards have been increasing in magnitude in the recent past, which suggests worry about changing environmental conditions. Hurricanes and flood events pose the greatest threat to New Orleans, which is a belief held by both residents and municipal planners and is supported by research into the social and physical vulnerability of the region.

Residents expect that the municipality address not only the current threat of coastal hazards but also the effects of climate change expected to impact New Orleans in the future (Brody *et al.*, 2008). This makes the relatively weak dedication of the municipal plans to identify threats posed by climate change in the future all the more surprising. Municipal dedication to continue considering the potential effects of climate change can only go so far, and at some

point, the expectation becomes a dedication to action to mitigate those effects. The explicit mention of climate change mitigation in the plan would help to further establish the role of New Orleans as a city committed to climate change foresight (New, 2018). This is alluded to in some of the planning documents of the parishes but is rarely declared outright, which is especially noticeable when considering the overall long-term plans of the parishes. Even these long-term plans can only carry so much weight when there exists hesitation to identify the underlying existential threat that requires mitigation in the first place. There is no doubt that there is some emphasis placed on the preparation of future conditions in these plans, but there are questions as to the magnitude to which these plans address the issues and whether or not the public is content with the degree of action committed to by municipal plans.

According to residents' response to expected municipal involvement in climate change mitigation, the answer to these questions appears to be doubtful. In general, respondents claimed that they believed that the local government should be involved in the mitigation of climate change. A similar number of people also believed that these mitigation actions should be implemented into the current municipal planning process. To these individuals, the issue of climate change as a topic cannot simply be put off and addressed in the future when more large-scale physical evidence is available to strengthen the theories behind climate change (Macintosh, 2013). At that point, it would be too late for local mitigation, especially in a region that is threatened to such a degree by the effects of climate change as New Orleans, perhaps most of all by sea level rise. It is a more reasonable task to plan for the future extent of sea level rise rather than attempting to implement plans when sea level rise already causes major damage to developed areas of the city.

Residents displayed mixed reactions to the current hazard mitigation plan, citing concerns with the flood drainage system as a primary weakness of the current response plan to major hazards. Because many individuals appear to correlate the current threat of sea level rise, hurricane events, and flood events with the future threat of these same hazards, it is probable that the concerns of the current response plan likely extend to concerns about the ability of the municipality to mitigate these same hazards on a larger scale in the future. If the municipality is unable to prevent damage from events now, then it would be impossible for them to prevent damage in the future when the events would be greater in magnitude (Macintosh, 2013). It is likely that individuals who explored the comprehensive master plan and hazard mitigation plan for their respective parish were underwhelmed by the seeming lack of commitment to the mitigation of future hazards. For residents, it is important to be able to understand the intentions of the plan. If the implementation of policies and projects that would aid in the strengthening of climate change resilience is not directly conveyed in the wording of the plan, then the meaning will not get through to residents. Further, if lay people are unable to decipher the intention of the plan and see past the hesitation to refer to the effects of climate change as they are, then public confidence in the governmental dedication to address climate change will be limited. As a result, residents perceive the expectations of their local government to be largely unmet.

It is in this way that clear communication is vital in the transmission of information in the plans, not only from residents to planners/policy-makers when developing projects but also from planners back to residents when providing them with the plan that will dictate the development and strengthening of the capability of their community. In the case of the threat of climate change, preemptive measures are vital to ensure the continued resilience of a population, as large-scale threats like sea level rise are extremely difficult to adapt to once they start to impact

an unprepared community. It is in this way that the major gap in the municipal coverage of resident risk perception is identified. As much effort as municipal planners allocate to strengthening resilience against current conditions, these changes would be rendered less effective unless they are also able to make preemptive developments to strengthen long-term resilience.

In the CPRA comprehensive plan, recommendations are given to governmental authorities as to how approaches to mitigating natural hazards should be improved to prevent current and future damage most effectively. The comprehensive plan notes the rapid implementation of current coastal hazard mitigation projects and developments, especially since Hurricane Katrina in 2005 (Coastal, 2017). However, additional focus is placed on the implementation of climate change policy and to account for the impacts of climate change in the planning process. Of the three parishes considered in this study, Orleans Parish is the only one that explicitly does this to any considerable degree. The CPRA specifies that the future effects of climate change should be cited in the prevention of development in areas designated as high-risk zones, not only about current hazards but also in terms of how these zones will be affected by future conditions. The enforcement of building and development restrictions in response to environmental impacts of climate change will aid in the prevention of economic damage by preventing development in areas that will likely be consumed by sea level rise. As a result, future damage can be prevented by restricting building structures that would be damaged in the first place. However, this can only be accomplished if the government makes a commitment to climate change as a central justification behind these changes. If this is not done, and development limitations are not tied to a major project such as that of climate change mitigation, then the possibility remains that these policy developments may be reversed in the future. To

prevent this, the local government must commit to the task of mitigating the effects of climate change and address the overarching impact on the social and physical aspects of the community of the region.

Low Incentivization of Mitigation Actions

The lack of focus on the threat of future hazards also manifests itself in a relative lack of individual action in efforts to increase personal resiliency. Municipalities can rarely manage development efforts on scales as small as individual properties, so the emphasis becomes incentivizing individuals to address mitigation themselves. However, this is only somewhat addressed in the comprehensive plans in New Orleans. As of right now, the primary focus on incentives is those provided to stormwater management and to new developments to keep them up to code. Significantly less priority is placed on incentivizing homeowners to take personal mitigation actions to increase household resiliency against coastal hazards. This sentiment as to incentive program implementation is also reflected in the master plan by CRPA. An emphasis in their recommendations is the promotion of market-based and tax incentives to prospective developers to limit construction in high-risk areas. However, just as in the parish plans, little focus is placed on personal mitigation actions as a target for incentivization. In a way, this isn't necessarily a problem since the parishes place a significant emphasis on the construction and development of structures to mitigate against the current threat of hazards. This places less of a burden on individual property owners to approach relatively large mitigation projects themselves. However, as with the general approach to coastal hazard mitigation, this begins to break down when the changing nature of coastal hazards as a result of climate change are considered.

In the survey, it was found that only about half of individuals have implemented personal mitigation actions to increase the resiliency of their home or property. In addition, a similar proportion of individuals reported owning flood insurance. These numbers are lower than expected since actions to increase personal resiliency and the ownership of flood insurance are both important methods through which individuals can prepare themselves for the risk of coastal hazards. This is especially interesting because residents' confidence in the capability of their municipality to prevent damage from their property in the event of an extreme coastal hazard is relatively low. As a result, there is a low level of both personal and municipal preparedness for hazard mitigation, from the perspective of residents. The negative effects that coastal hazards have on residents are only predicted to increase in the future, so mitigation must occur as soon as possible on as fine a scale as possible to prevent vulnerable communities from being left relatively defenseless in the event of a major hazard event.

An important way of ensuring that these mitigation actions are adopted is the provision of incentives at a governmental level. A majority of respondents in the survey believed that the promotion of incentives by their parish government should be a high priority. This is especially interesting when because the moral hazard issue appears as an underlying trend in the support of structural and non-structural projects. It seems obvious that individuals who have not already taken personal actions would be in support of the incentivization of these actions, but it also seems as though individuals who have taken actions are also in support of incentives. This is important to consider since it means that, regardless of the number of individuals who have already adopted mitigation measures and who own flood insurance, residents should still be in support of the incentivization of future adoption of these resilience measures.

This result also suggests that individuals appear to be in favor of incentive programs despite political ideology, which seems to be a factor typically considered when arguing against incentive programs that would mitigate climate change (Shao *et al.*, 2017c). The residents of New Orleans possess foresight regarding the threat posed by the effects of climate change, so they likewise possess foresight into the steps that are necessary to reach a level of resiliency that is capable of handling these future effects. These trends observed in the survey suggest that, despite relatively low-level adoption of mitigation measures, residents are in favor of the incentivization of these projects to protect as many private citizens as possible. As a result, a low level of adoption should be viewed as a trend that can be improved by the implementation of new incentive projects. It is for these reasons that the approach to incentives by local government planners should be reconsidered to place a larger emphasis on personal mitigation for existing home and property owners.

CONCLUSIONS

The New Orleans region of Louisiana has received a considerable amount of attention in recent years for the combination of natural hazard risks that are imposed on the community. The region exhibits extraordinarily high levels of social vulnerability when faced with the pressures of hurricanes and flood events and rising sea levels as a result of the effects of climate change. Because of the high pressures placed on the residents of New Orleans by these coastal hazards, municipal master plans and hazard mitigation plans must establish sufficient groundwork for dealing with the current and future threats of these hazards. To do this, the local government plans must adequately cover those issues that the general public is most worried about in addition to providing mitigation in areas in which residents expect governmental action to be taken. This study aimed to identify a possible gap in this communication between municipality and residents to determine whether or not the concerns of the residents of this highly vulnerable region regarding coastal hazards are covered by municipal plans. Through the results of the study, three main findings were identified for consideration.

First, the approach to mitigation of current hazards by the local governments of Jefferson, Orleans, and St. Tammany Parishes is strong and sufficiently addresses the issues for which the residents of those parishes worry about the most. In addition, the level of detail and commitment to mitigation on small and large scales by the municipalities meet the residents' expectations as to the degree of governmental action and responsibility regarding these hazards. Although resident confidence in the current state of the municipal hazard mitigation plans is not

exceptionally high, it is believed that this is caused by a lack of communication as to the content of the plans rather than the contents of the plans themselves. In general, the items prioritized in the master plans and hazard mitigation plans of the three parishes focus on those issues that are most influential in the social vulnerability of the region and influence the worry of coastal hazards most in residents of New Orleans. From these results, it becomes clear that the parish governments are aware of the social vulnerability faced by the region and of the issues prioritized by residents. In the case of mitigation of those hazards currently threatening the New Orleans metropolitan area, no significant gap exists between the priorities and expectations of residents and the local government.

Second, the approach to mitigation of climate change by the local governments of Jefferson, Orleans, and St. Tammany Parishes is not nearly as strong as mitigation of current hazards. Although the threat of future hazards is considered in the plans of these parishes, the effects on the region specifically relating to climate change are hardly mentioned. It is believed that this was done to avoid the politicization of the issue of climate change that exists in America so that necessary mitigation measures could be implemented with little controversy or backlash. However, the survey of residents reveals that this is simply not enough. A majority of surveyed residents expressed the belief that not only does the local government need to be responsible for climate change mitigation, but that climate change mitigation should be implemented into the current plan. In addition, the perception of urgency of climate change mitigation was found to be significantly correlated to support of structural, non-structural, and incentive-based mitigation projects. It is clear that residents expect the local government to be thoroughly involved in the mitigation against the effects of climate change now, and the plans of these parishes do not reflect that. As a result, the significant gap between public perceptions of coastal risk and

municipal plans is the lack of coverage of the threat posed by climate change in the current plans of Jefferson, Orleans, and St. Tammany Parishes.

Third, there are not enough incentive opportunities for individual home and property owners to undertake personal mitigation measures to increase the resiliency of their household. Current incentive options in Jefferson, Orleans, and St. Tammany Parishes mostly focus on limiting new development in high-risk areas, such as in FEMA's Special Flood Hazard Zone. These incentives function to prevent new construction projects in high-risk areas and encourage the increase of structural resiliency on existing developments, but they do not help individual residents in mitigating coastal hazards on a small scale. Only about half of the respondents surveyed reported owning flood insurance or having undertaken personal mitigation actions. Regression analysis of trends related to support of municipal projects suggests that, contrary to expectation from the moral hazard argument, individuals who have already invested in their resiliency are more likely to support further projects and incentives being provided to mitigate the threat of coastal hazards. As a result, it would be in the best interest of municipalities to develop incentive programs to allow residents to more easily approach personal mitigation actions and improve their resiliency on a scale that would otherwise be inefficient for the municipality itself to operate on.

Through completion of the study, several limitations were identified to build on in future research. First, the spatial extent of the survey only considered the three most populated parishes in the New Orleans metropolitan area. This was done to ensure the most robust response for the sake of comparing respondent trends to municipal plans, but the conclusions identified would be strengthened if all parishes in the metropolitan area were eventually considered. In addition, the survey was created to address risk perceptions of coastal hazards specifically. The gap in plan

coverage was later identified to be that of climate change mitigation, so a subsequent survey should include more specific questions related to climate change and the specific predictions for future coastal hazards held by residents. Further, this study only considers the output of the municipal planning process and does not consider shortcomings in the process itself. While a gap was identified in the coverage of climate change hazards in current municipal plans in this study, potential sources of this gap in the communication between residents and the local government during the municipal planning process were not considered. Finally, the relatively low pseudo R-squared values for most of the models mean that some of the relationships that were found to be almost significant could display a correlation if specific models are constructed testing for those relationships. An example includes the relationship between insurance ownership and support of incentive projects, which could theoretically display a negative correlation through the moral hazard argument but that was not observed in this study. These points of interest could be expanded on in future studies.

The findings detailed in this study present some questions that can serve as the basis for future research into coastal risk perceptions and municipal coverage of hazard resiliency. First, the extension of hazard risk perception to the expectation of future events could serve to identify specific points of concern regarding the effects of climate change. Climate change as a process is recognizable, but also carries preestablished opinions and perceptions. As a result, research into future perceptions of risk independent of climate change would provide an idea of how exactly layperson perception of intensifying trends applies to individual hazards. This would allow for a more directed focus on which specific hazards should be addressed when planning mitigation actions for future hazardous conditions. Second, future studies could analyze the municipal planning process itself rather than just the final product of planning efforts to identify where gaps

in communication of climate change priority and language manifest. Doing so would work to prevent the potential for miscommunication in both future planning processes and implementation of plans before they happen. This will be especially important as the effects of climate change continue to grow in magnitude in the future, particularly in vulnerable coastal regions such as New Orleans. Third, future research into personal adoption of mitigation projects should be explored to identify factors that can be applied to improve the rate of adoption in high-risk areas. To ensure that coastal communities are best prepared for the future effects of climate change, mitigation must be implemented on both large and small scales. By identifying trends in how residents view the tradeoffs of personal mitigation projects, better efforts can later be made in the municipal planning and implementation processes to elevate community resilience in southeastern Louisiana in preparation to manage the future effects of climate change.

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APPENDICES

Appendix A. Copy of the Survey

1. Have you experienced flood damage to your property from hurricane events within the past 10 years?
 - a. Yes
 - b. No

2. For the following events, do you think each of them has increased, decreased, or stayed the same in the past 30 years?

Increased	Decreased	Stayed the same
a. Number of hurricanes		
b. Strength of hurricanes		
c. Number of floods		
d. Degree of flooding		
e. Level of coastal waters		
f. Amount of rainfall		
g. Frequency of heavy rain events		

3. Do you think that rising sea levels contribute significantly to coastal erosion in Louisiana?
 - a. Strongly agree
 - b. Somewhat agree
 - c. Neither agree nor disagree
 - d. Somewhat disagree
 - e. Strongly disagree

4. Which of the following risk factors do you most often associate with hurricanes?
 - a. Flooding from storm surge
 - b. Flooding from rainfall
 - c. Wind damage
 - d. All of the above

5. How influential do you think climate change is to the impact that natural disasters have on your community?
 - a. Very influential
 - b. Somewhat influential
 - c. Neutral
 - d. Not very influential
 - e. Not at all influential

6. How concerned are you with potential changes in climate in the near future?
 - a. Very concerned
 - b. Somewhat concerned
 - c. Neutral
 - d. Somewhat unconcerned
 - e. Very unconcerned

7. Do you believe that your household is sufficiently prepared for a potential flood or hurricane?
 - a. Yes
 - b. No
 - c. Undecided

8. If not, what specific issues should be addressed to ensure that you are sufficiently prepared? (select all that apply)
 - a. Strengthening the outside of your home
 - b. Elevating your home
 - c. Stocking more emergency supplies
 - d. Modifying your plan of action in an emergency situation
 - e. None of the above

9. If you chose none of the above, what other issue would you address to be better prepared? (open-ended)

10. Do you own your own home, pay rent, or something else?
 - a. Own
 - b. Rent
 - c. Other

11. Do you currently have flood insurance?
 - a. Yes
 - b. No

12. If your answer to (11) is yes, why do you have flood insurance?
- Required
 - To feel safer
 - Both
13. If you have flood insurance, how much do you pay for the yearly premium? (open-ended)
14. If you currently do not have flood insurance, what would be your biggest motive to purchase it in the future?
- lower premiums
 - better coverage
 - increased flood risk as revealed from new scientific data
 - experience with flood damages
15. Do you reside within the Special Flood Hazard Zone or 100-year floodplain?
- yes
 - no
 - don't know
16. If your answer to Q16 is yes, how did you find out you reside within the 100-year floodplain? (open-ended)
17. In general, how much do the following sources of information influence your knowledge about flood disasters in your community?
- No influence Low influence Moderate influence High influence
- Local newspaper/TV news
 - Regional news
 - National newspaper/TV news
 - Online social networking sites (i.e. Twitter, Facebook, Instagram)
 - Online search engines (i.e. Google, Bing)
 - Family, friends, or neighbors
18. If you heard of or perceive an increased risk of a flood disaster in your community, how likely would you be to search for the following concepts from your primary sources of information?
- Civil infrastructure (i.e. dams, levees)
 - Information from the government (i.e. evacuation routes, updated conditions)
 - Weatherproofing your home (i.e. sandbags, pumps)
19. What would you consider a reliable source of information in the context of disaster communication?

- a. Local government
 - b. Federal or State government
 - c. Scientists
 - d. Online Social Media site (i.e. Twitter, Facebook)
 - e. Friends and family members
 - f. Community groups (i.e. NGOs, churches, etc.)
20. Have you personally taken any measures to make your home more resistant to flood hazards before a disaster?
- a. yes
 - b. no
21. If you have, what actions have you taken? (you can select more than one option)
- a. Strengthening your home's outer envelope---notably roof and wall systems, doors, glazed openings, and the foundation
 - b. Elevating your home
 - c. Building retrofits to your home to resist flooding and erosion impacts
 - d. Purchasing sandbags or boards to reinforce your home
 - e. Acquiring a personal generator
 - f. Preparing an emergency kit
 - g. Other
22. If other, what specific action have you taken that we did not list here? (open-ended)
23. Have you heard of any of these federally funded programs?
- a. Hazard Mitigation Grant Program
 - b. Pre-Disaster Mitigation Grant Program
 - c. Flood Mitigation Assistance Grant Program
 - d. None
24. If yes to (23) have you, applied for a grant through one of these programs?
25. How involved do you expect the city of New Orleans/Houston to be in preventing damage to your property in the event of a hurricane or flood event?
- a. Very involved
 - b. Somewhat involved
 - c. Neutral
 - d. Not very involved
 - e. Not at all involved

26. The Regional Planning Commission was created to be responsible for the planning and development of the New Orleans metropolitan area in addition to the city proper of New Orleans. How involved do you expect the Regional Planning Commission to be in preventing damage to your property in the event of a hurricane or flood event?
- Very involved
 - Somewhat involved
 - Neutral
 - Not very involved
 - Not at all involved
27. If you live outside of the New Orleans/Houston city limits, do you think the city should consider how prepared your community is to handle flood events when planning extensions of the levee system?
- Strongly agree
 - Somewhat agree
 - Neither agree nor disagree
 - Somewhat disagree
 - Strongly disagree
 - I live within the New Orleans city limits
28. Do you think that the local government is doing enough in terms of flood prevention for communities inside the levee system?
- Y
 - N
 - Undecided
29. Do you think that the local government is doing enough in terms of flood prevention for communities not contained within the levee system?
- Y
 - N
 - Undecided
30. Do you think the local government is prepared to handle the threat posed by a major flood?
- Y
 - N
 - Undecided
31. If not, then what factor needs the most improvement?
- Levee system
 - Drainage of water within the city
 - Emergency service availability
 - Risk communication

32. Considering the recent major city projects aimed at strengthening and developing the levee system, do you think that the levees should continue to be a PRIMARY point of concern for development in the near future?
- Y
 - N
 - Undecided
33. Would you support tax increases to strengthen the current levee system?
- Will support
 - Might support
 - Neutral
 - Might not support
 - Will not support
34. What issues should be prioritized by the government in increasing community resilience for the New Orleans/Houston metropolitan area? Rank the importance of each.
- Very important Somewhat important Not very important Not at all important
- Improvement of the levee system through strengthening current levees and adding new levees.
 - Preservation of the coastline to protect coastal communities.
 - Restoration of the coastline to protect coastal communities.
 - Increasing funding on education for emergency preparation and evacuation.
 - Improving the flood warning system.
 - Improving the floodwater drainage system.
 - Providing incentives for property owners to relocate structures in threatened areas.
35. To implement any of the policy options from (34), how much of your yearly gross income (%) would you be willing to pay in taxes to your local government for mitigation purposes? (Scalar bar)
36. Do you think that the local government should include protections for future impacts of climate change in its plan now?
- Strongly agree
 - Slightly agree
 - Neither agree nor disagree
 - Slightly disagree
 - Strongly disagree
37. How involved do you expect the local government to be in preventive measures related to climate change?
- Very involved
 - Somewhat involved

- c. Neutral
- d. Not very involved
- e. Not at all involved

38. How confident are you in the current disaster relief plan in New Orleans/Houston?

- a. Very confident
- b. Somewhat confident
- c. Neutral
- d. Not very confident
- e. Not at all confident

39. Which age group do you belong?

- a. 18-34
- b. 35-54
- c. 55-64
- d. 65 and over

40. Which of the following best describes you?

- a. White
- b. Black or African-American
- c. Native American or Alaska Native
- d. Asian
- e. Native Hawaiian or Other Pacific Islander
- f. Other

41. Are you Hispanic?

- a. Y
- b. N

42. Gender

- a. Male
- b. Female

43. How many years have you lived in your community?

- a. One Year or Less
- b. 2-5 Years
- c. 6-10 Years
- d. 11-20 Years
- e. More than 20 Years

44. Which of the following categories best describes your highest level of education?
- a. Less than High School
 - b. High school graduate
 - c. Some college
 - d. 2 year degree
 - e. 4 year degree
 - f. Professional degree
 - g. Doctorate
45. What was your household income last year before taxes? Note: this information will remain strictly confidential and will only be used for statistical purposes
- a. Under \$10,000
 - b. \$10,000 - \$19,999
 - c. \$20,000 - \$29,999
 - d. \$30,000 - \$39,999
 - e. \$40,000- \$49,999
 - f. \$50,000 - \$74,999
 - g. \$75,000 - \$99,999
 - h. \$100,000 or more

Appendix B. IRB Approval

THE UNIVERSITY OF
ALABAMA[®] | Office of the Vice President for
Research & Economic Development
Office for Research Compliance

September 16, 2020

Wanyun Shao
Department of Geography
The University of Alabama
Box 870322

Re: IRB # 20-08-3810: "Two-City Coastal Hazards Survey"

Dear Dr. Shao,

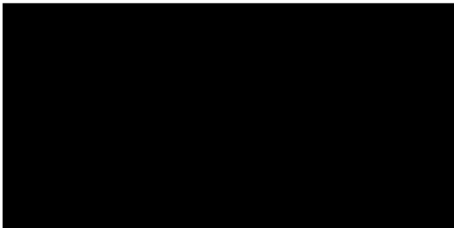
The University of Alabama Institutional Review Board has granted approval for your proposed research. Your application has been given exempt approval according to 45 CFR part 46. Approval has been given under exempt review category 2 as outlined below:

(2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:

(i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects

The approval for your application will lapse on September 15, 2021. If your research will continue beyond this date, please submit the annual report to the IRB as required by University policy before the lapse. Please note, any modifications made in research design, methodology, or procedures must be submitted to and approved by the IRB before implementation. Please submit a final report form when the study is complete.

Please use reproductions of the IRB approved informed consent form to obtain consent from your participants.



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