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Adaptation Preferences and Responses to Sea Level Rise and Land Loss Risk in Southern Louisiana: a Survey-based Analysis

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ADAPTATION PREFERENCES AND RESPONSES TO SEA LEVEL RISE AND LAND LOSS RISK IN SOUTHERN LOUISIANA: A SURVEY-BASED ANALYSIS

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Sandra Njeri Maina

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To: Interim Dean Michael R. Heithaus
College of Arts and Sciences

This thesis, written by Sandra Njeri Maina, and entitled Adaptation Preferences and Responses to Sea Level Rise and Land Loss Risk in Southern Louisiana: a Survey-based Analysis, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this thesis and recommend that it be approved.

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ABSTRACT OF THE THESIS

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Currently, southern Louisiana faces extreme land loss that could reach an alarming rate of about one football sized swath of land every hour. The combined effect of land subsidence and predicted sea level rise threaten the culture and livelihood of the residents living in this region. As the most vulnerable coastal population in Louisiana, the communities of south Terrebonne Parish are called to adapt by accommodating, protecting, or retreating from the impacts of climate change. For effective preparation planning, the state of Louisiana needs to 1) understand the adaptation preferences and responses of these residents and 2) involve these vulnerable communities in adaptation related decision making. The study uses a survey-based methodology to analyze current adaptation preferences. Findings suggest that protection is the preferred adaptation response. The present study additionally uses participatory techniques to develop a land loss awareness mobile application to illustrate the importance and benefits of community collaboration.

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CHAPTER I. INTRODUCTION

South Terrebonne parish is home to a community of people that have lived off the land and water for centuries, sharing a unique connection to their environment. Their history began with involvement in the sugar industry during the 1880s which transitioned to oil and gas extraction as well as commercial fishing by the mid-1900s (Gould 1984, Woodman 1979). Today the parishes of coastal Louisiana are responsible for providing about one fourth of the nation's supply of crude oil and natural gas. Coastal Louisiana has also become the number one producer of shrimp, oyster, and crawfish in the Unites States (Benoit et al. 2010). Unfortunately, the area has faced dramatic geomorphologic changes that result from centuries of industry and urbanization related activities (Austin 2006). From the years 1932 to 2000, Louisiana has lost approximately 25 percent of land area (approximately equivalent to the size of Delaware). With the persistence of the current land loss rate and additional projected impacts of sea level rise, Louisiana will experience a land loss rate equivalent to losing an average of one football field per hour (Couvillion et al. 2011).

There are currently restoration efforts being employed, such as Louisiana's 2012 Coastal Master Plan. As the most recently passed restoration legislation, the Coastal Protection and Restoration Authority (CPRA) has outlined several hundred restoration projects in this plan. However, these projects lack substantial involvement with the community. As the motivation behind our study, we believe that if there was substantial community involvement, the detrimental impact of land loss on the livelihoods of these communities would be recognized and fuel the urgency of protecting both the land and culture. Therefore, the present study strives to make evident the importance of

collaborating with the vulnerable populations of south Terrebonne Parish as the state begins climate change adaptation preparation and planning.

In order for planning at the state level to be effective, we believe that adaptation preferences at the community level must complement that of the state. However, analytical research in this field has not been completed in southern Louisiana. Consequently, the first objective of our work is to provide an assessment of local adaptation preferences for six of the most vulnerable communities in south Terrebonne Parish: Dularge, Dulac, Montegut, Chauvin, Isle de Jean Charles, and Pointe Aux Chenes. For any vulnerable population, climate change adaptation involves one of the following three categories defined by the Intergovernmental Panel on Climate Change (IPCC): retreat, accommodation, and protection. The two adaptation options analyzed in the present research are retreat and protection. The individual preference of retreat was measured by residents' rated likelihood of community abandonment by the year 2050 while protection was measured by evaluating the belief of successful future coastal wetland restoration.

Literature (Altman and Low 1992, Burley et al. 2007, Grothmann and Patt 2003, Tuan 1977) suggests that the emotional bond an individual has with place and his/her perception to risk influences their motivation to act. The people of south Terrebonne Parish have interacted with the land for centuries and created a bond that is ultimately being impacted by land loss and in turn influencing behavior. The bond and past experiences with the land have enabled the communities of coastal Louisiana to have a heightened awareness of the impacts of climate change, a rare occurrence not only in our nation but globally as well (Doherty and Clayton 2011, Leiserowitz 2006). As such, we

distributed 125 surveys within the five aforementioned communities and empirically tested the hypotheses that 1) south Terrebonne Parish residents are well-aware of the coastal hazard of land loss, 2) risk perception to land loss positively influences proactive adaptation, and 3) place attachment negatively influences proactive adaptation. Findings indicate that residents have a keen sense of land loss and its environmental impacts such as vegetation decrease. The change in extreme weather patterns and resulting increase in vulnerability that accompany climate change are also recognized by residents. They additionally feel that their quality of life is being threatened. In the end, our results suggest that the preferred adaptation effort is restoration because of the strong connection these residents have to their communities.

Although parish residents' adaptation preferences reflect those of the state, these restoration efforts will prove ineffective without knowledge and consideration of the cultural risks. The second objective of our research was to determine a way to increase the recognition of the cultural impacts of land loss. The approach used is one discussed at large in social science literature – participatory action research (PAR). At its essence, PAR dictates that the researcher holds no power over the community members and requires collaboration with the communities (Cornwall and Jewkes 1995, Taylor et al. 2011). Collaboration thus fosters community involvement in all parts of the research (e.g., identifying the problem, determining a solution, data collecting, etc.). There has been little documentation suggesting successful integration of this methodology because of limitations such as the following: researchers were often seen as authoritative, communities wanted ownership of the developed projects, there was a lack of support

from relevant stakeholders, and there was no follow up or launching of the developed projects (Mercer et al. 2008).

As per PAR, the communities identified the lack of cultural awareness and suggested the use of technology. The application of information and communications technology (ICT) for disaster management has been discussed at length (Asimakipoulou and Bessis 2010, Shklovski et al. 2010, Subedi 2010); however, it has not been considered as a potential avenue for archiving and educating the cultural risks of natural disasters. The adoption of technology for the case of land loss awareness would be an innovative use for pre-disaster preparation. Thus, the concept of a land loss awareness mobile application was established and lead to the development of *Vanishing Points*™. The application maps locations of cultural significance, providing geographical information including animations of land loss from 1973 to 2010. Not only does it identify these locations, the application also tells their stories through the voices of the community members themselves. Historical and current pictures from the residents are also included to show the true geomorphology of the land as opposed to what is currently portrayed on illustrated maps.

Development of the application brought to light several challenges of PAR such as the extensive commitment of the researcher's time. However, the benefits of the ongoing project greatly outweigh the hardships. By creating a community centered application, the residents are able to take ownership of a product that serves as a tool to showcase the progression of land loss at a local level and the vulnerable culture of south Terrebonne Parish. *Vanishing Points*™ also serves as an archive of cultural history that informs and involves the younger generation that is responsible for saving their ancestral

lands. As a finished product *Vanishing Points*™ will serve as a voice for the community and create a bridge between state and national institutions – a necessary aspect of effective decision making and disaster planning in coastal Louisiana. It will also serve as an example of how decision-makers can involve community members and incorporate the breadth of knowledge contained within these communities as a result of their past and present experiences with land loss (Ali 1999, Burley 2010).

CHAPTER II. BACKGROUND AND LITERATURE REVIEW

The Communities of South Terrebonne Parish

There are six communities that comprise the "5 fingers" of south Terrebonne Parish (see Figure 1): Dularge, Dulac, Montegut, Chauvin, Isle de Jean Charles, and Pointe Aux Chenes. Collectively, the population of about 10,233 residents (US Census, 2010) with origins that date back to the early 1700s. Seeking peace and wealth from their native countries, French, African, German, Caribbean, Chinese, and Slavic immigrants were integrated among the two main dominant populations of southern Louisiana – 1) Native Americans relocated from Mississippi and Alabama and 2) Acadians (Cajuns) exiled from Nova Scotia (Gramling and Hagelman 2005, Wallace et al. 2001). Their long withstanding socio-economic history begins with the rise of the sugar industry in the late 1800s (Gould 1984). After the Civil War, the people underwent economic hardships that lead to a shift of lifestyle that revolved around the land. Activities such as trapping for furs, hunting, and fishing became common knowledge (Woodman 1979). During the late 1870s, timber was discovered as an additional source of revenue for the state. When the cypress forests were nearly depleted by the 1930s, commercial shrimping became the most influential industry (Austin 2006). After the surge of flood control projects in the early to mid-1900s (Houck 1986), southern Louisiana entered the petroleum industry. During WWI, Louisiana played an influential role for providing transportation fuel. By the Second World War, offshore extraction began as a result of the first pipeline laid down by the Texas Company (today known as Texaco) in 1942 (Lindstedt 1991, Pratt 1980).

Today, Louisiana is the number one producer of shrimp, oyster, and crawfish in the United States. Additionally, about one fourth of the nation's supply of crude oil and natural gas moves through the state's wetlands (Benoit et al. 2010). Despite the wealth of resources in coastal Louisiana, most benefits of these industries are passed to energy companies and not to the local people. These communities are also confronted with the environmental consequences of industry related activities such as canal pipeline dredging and waste disposal (Austin 2006). On top of these environmental issues, the communities of south Terrebonne Parish also face the risk of losing their land and culture to land loss.

Extreme Land Loss in South Louisiana

From 1932 to 2010, Louisiana has lost about 25 percent or 1,883 square miles of land area (approximately equivalent to the size of Delaware). If land loss persists at the current rate of 16.57 square miles per year, Louisiana would be losing an average of one football field per hour (Couvillion et al. 2011). In a 28 year time span, dramatic land loss can be seen in south Terrebonne (Figure 2). Although Louisiana coastal land loss is a dynamic and complex process (Fisk and McFarlan 1955, Blum and Roberts 2012), major contributors include the following: construction of levees in the Mississippi River; the supporting infrastructure of the oil and gas industry; and the impacts of climate change (Walker et. al 1987).

a. Levee construction

The wetlands of southern Louisiana are a product of the meandering nature of the Mississippi River. Delta relocation, a process that occurred every 1,000 to 1,500 years,

involved the subsidence and retraction of wetlands (Penland et al. 1988). However, this once natural process of sediment deposition has been altered due to the construction of levees. Levees are beneficial for agricultural activity and urban growth. On the other hand, alteration of the Mississippi River's hydrologic functions has created a substantial decrease of sediment storage rates (Blum & Roberts 2009) and inhibited the process of natural wetland construction.

b. Oil and gas industry

As previously described, the oil and gas industry molded the economic foundations of Louisiana's coastline. Unfortunately, there were deleterious environmental impacts that physically impacted the coastline. About 958.43 square miles of wetland loss can be directly attributed to oil and gas removal from 1955 and 1980 (Foy 1989). The dredging of canals for pipelines and navigational purposes explains about 30 to 59 percent of wetland loss from 1956 to 1978 (Turner and Cahoon 1988). It was once thought that direct land loss (e.g., from dredged canals) was the only factor in Louisiana's disappearing coastline (Turner 1997). However, long-term indirect impacts have been identified as more damaging than direct land loss. For example, the widening of canals and subsequent saltwater intrusion resulted in increased salinity levels that negatively impacted coastal wetland vegetation (Ko and Day 2004, Neff et al. 2003, O'Rouke and Connolly 2003) as seen in Figure 3.

c. Sea level rise

Estimated by the National Ocean Survey (NOS) tidal records, coastal Louisiana currently has the highest relative sea level rise (RSLR) rates in the Gulf of Mexico – 9.24 mm yr^{-1} (http://tidesandcurrents.noaa.gov/sltrends/). This alarming rate is a combination of global and local sea level rise trends. Globally, sea level rise is primarily attributed to glacial melt and thermal expansion of the ocean. IPCC Fifth Assessment Report states an average global sea level rise of 3.2 [2.9 to 3.6] mm yr^{-1} between 1993 and 2010. Locally, land subsidence plays a significant role in the estimated sea level rise of 11.1 – 12.9 mm yr^{-1} seen in Terrebonne Parish (Penland et al. 1987). As RSLR continues to increase, more wetlands will be converted from freshwater to brackish marsh and eventually open water. Storm surge values may also increase anywhere from double to five times the current level (Smith et al. 2010). There may also be major erosion and inland migration of barrier islands (Scavia et al. 2002).

Climate Change Adaptation

As defined by IPCC, adaptation is an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". For the residents of south Terrebonne Parish, adaptation to natural hazards such as hurricanes, and flooding has been an integral aspect of their lives. From the years 1851 to 2008, Louisiana has experienced a total of 106 landfalling tropical storms and hurricanes (Roth 2010). With flooding as the most prominent impact from these storms, residents have protected their homes by raising them on "stilts" or concrete pilings. However, with the additional threat of climate

change, the coastal communities of south Terrebonne Parish are called to further adapt to the aforementioned effects of land loss and climate change.

According to the IPCC (2001), the variety of climate change related adaptation strategies can be attributed to three main categories – retreat, accommodation, and protection. Retreat involves displacement away from the risk, accommodation describes adjustments to compensate for changes, and protection consists of building structures to combat the physical impacts. The option that has received the most attention thus far is retreat. In Bangladesh for example, a region facing similar physical risk to Louisiana, residents move with the intention of staying close to their origin because of reasons such as affordability, hopes of gaining the land back in the future, and desire to not lose their culture (Hutton and Haque 2004).

For the present study to assess the climate adaptation preferences and practices of south Terrebonne Parish, the residents' place attachment, and risk perception must be analyzed (Stedman 2003). Place attachment has been described as a "person-place bond that evolves from specifiable conditions of place and characteristics of people" (Shumaker and Taylor 1983). For the residents of southern Louisiana, the bond resulted from generations of interactions and experiences with the land and its people, thus creating an emotional bond that influences behavior. Place attachment must be understood if residents are to assume a stronger role in the protection and restoration process (Burley 2010). With the dramatic change of place in the last few decades, these coastal communities face a respective change of identity which must be considered (Burley et al. 2007). Residents' perception to the risk of land loss and climate change influences place attachment (Burley 2010), and must also be analyzed because of its

effect on an individual's motivation to act. Although risk perceptions are important in predicting behavioral intentions, there is sparse literature that uses risk perceptions as independent variables to predict action (O'Connor et al. 1999). Additionally, there is a need to look at the effect of human-environment interaction at scale smaller than county-level (Boruff et al. 2005). As a result, one focus of our study is to assess the risk perceptions, place attachment, and adaptation preferences at a community.

Community Involvement

The second focus of the study is motivated by the lack of successful climate change adaptation strategies that directly involve the communities at risk. As seen in the vulnerable communities of Bangladesh and Atlantic Canada, it is important to involve the vulnerable population in adaptation planning and mitigation because of the innovations they have to offer as a result of past and present experiences (Ali 1999, Chouinard et al. 2008). Unfortunately, current state legislations for wetland restoration in south Terrebonne Parish do not take this into account. Louisiana's 2012 Coastal Master Plan, approved for legislature on May 22, 2012, outlines approximately 400 restoration, structural risk reduction, and non-structural reduction projects such as bank stabilization, earthen levees, and flood proofing, respectively. Of these 400 projects, the Coastal Protection and Restoration Authority (CPRA) identified 109 project that can dramatically improve the current conditions of south Louisiana's deteriorating coast. CPRA developed a predictive model that assessed the possible effects of all the projects relative to the maximum risk reduction and maximum land restored. When using these evaluation tools, the Master Plan indicated that approximately three percent of Louisiana's population will

not be included in the restoration plans. This statement brings to question the involvement and input from these neglected communities, especially in south Terrebonne Parish.

During the drafting period of the Master Plan, ten community meetings were held from the months of July to September 2011 where residents were asked "What is most important to you?" Of those meetings, only one occurred in south Terrebonne Parish – August 10, 2011 in Chauvin. In addition, upon release of the draft in January 2012, the closest public hearing to the residents of south Terrebonne occurred in Houma on January 24, 2012. Stakeholder outreach meetings were also held with Bayou Grace (provider of community services) on June 8, 2011 and United Houma Nation (one of three Native American tribes in south Terrebonne) on November 2, 2011.

In the final Master Plan, CPRA acknowledged that the outreach and engagement process *"showed citizens' passion for and knowledge about the coast"* and *"want to capitalize on that local knowledge"*. Yet the citizens and stakeholders *"will not help the state identify solutions"*. The current actions by the state represent problem-solving using a top-down approach. The solutions of wetland restoration are not developed with the communities that live with the consequences of land loss. Instead, strategies are created for them. The following concepts are ones that represent a bottom-up approach that should have been used to create the Master Plan: consideration of residents' time and convenience, collaboration, and ownership. Application of these concepts can be achieved using participatory action research (PAR). The unconventional approach of collaboration allows for community engagement that can increase an appreciation for proactive adaptation as long as it is accompanied by community awareness (Chouinard et

al. 2008). State actions such as the Master plan will be ineffective if it does not take into account the existence of community (Burley et al. 2007). Consequently, the second focus of our study is to follow PAR methodology and develop a community-centered mobile application that increases the awareness of land loss on the communities of south Terrebonne Parish.

Participatory Action Research

Conventional research involving natural hazards focuses solely on the physical risk. The corresponding methodology often neglects the concerns of the population at risk (Mercer et al. 2008) thus undermining the true risk these vulnerable populations face. Although multidisciplinary approaches are looked down upon as less reliable and lacking in academic credibility, approaches such as PAR are needed for improving the sustainability and appropriation of adaptation strategies (Cornwall and Jewkes 1995).

Seen more as an attitude as opposed to a set of techniques, PAR is a methodological and philosophical approach that requires the researcher to collaborate with community members (Taylor et al. 2011). Collaboration ensures that the values and norms of the community are understood and respected (Mercer et al. 2010). It is important the community members are seen as knowledgeable co-researchers that have the capability of problem-solving. PAR recognizes that those who are impacted by a natural hazard are the ones that hold valuable information necessary to solve these problems (Ali 1999).

Contradictory to PAR, conventional top-down research often assimilates vulnerability with victimization. As a researcher, such a mindset creates a sense of

misfortune and creates a gap between the researcher and the people (Park 1993). The PAR methodology closes this gap by creating a learning environment (Mercer et al. 2008, Taylor et al. 2011) where the researcher assumes the role of a novice as opposed to a teacher. The process that harbors a student-teacher relationship (Figure 4) begins with a decolonization of self. The researcher must accept, evaluate, and overcome the existence of any assumptions or biases about the population of interest (Smith 1999). The process elicits transparency of the researcher that is necessary to proceed to the next step of the process – collaborative conceptualization of the problem. Once the researcher has gained the trust and acceptance of the community, the researcher transfers the power of identifying the research problem to the people (Cornwall and Jewkes 1995). Once identified, the data may be collected through a variety of methods that must allow the people to tell their story in a way they can understand (Mercer et al. 2008). Three of the most common methods for data collection are focus groups, interviews, and observation (MacDonald 2012, Smit and Wandel 2006). During the information gathering, it is essential that the researcher reflects frequently in order to respond to the different needs and perceptions of the people (Bergold and Thomas 2012). The processes of data collection, reflection and action are cyclical in nature (Park 1993) – an important aspect of PAR that differs from conventional methods.

a. Benefits and challenges

A product of the cyclical nature of PAR is the transfer of power from the researcher to the local people. Table 1 identifies several differentiations between the conventional and participatory research processes. As the driving force behind the

research, the local people become active participants of the research as opposed to studied subjects. The communities are thus involved in all steps of the research process. Contributions from community members throughout the process create a sense of empowerment for the participants – their once unrecognized diverse knowledge and experiences are valued. With empowerment comes skill development that will promote self-advocacy and increase the community's coping ability in the future (Mercer et al. 2008).

In order to ensure the aforementioned benefits, the researcher must overcome several challenges and accept various limitations of participatory research. First and foremost, one has to understand that PAR is conducted in the complex environment of the community. The most prominent challenge is the barrier of time. Researchers must be prepared for the significant amount of time it takes to work with the local people midst their daily-life schedules. Information gathering has to occur at times and locations most convenient and comfortable to the local people. The complex hierarchal and network characteristics of a community also create a variety of perspectives, agendas, levels of interest, and motivation for the research project (Cornwall and Jewkes 1995).

Although the local people are meant to be co-collaborators in PAR, researchers additionally face the challenge of being seen as an authoritative figure. Ideally, communities should have control and ownership of the research; however, the researcher will always have their own agenda as an outsider to the community (Mercer et al. 2008). Consequently, the researcher should allow for the people to communicate freely through conversations as opposed to rigid interviews. More often than not, community members

are willing to share their knowledge and experiences for the security and protection of their future (Feyerabend et al. 2007). This presents another challenge – the potential of collecting large amounts of quantitative data. The researcher must be able to accept all the knowledge yet retain the relevant information.

Documentation of successful PAR integration in the field of natural hazards is sparse. However, a few case studies conducted by the United Nations Centre for Regional Development (UNCRD) have proven the potential of community collaboration particularly in disaster preparedness and management. Termed community based disaster management (CBDM), the UNCRD assessed the impacts of community based projects in a three year project called Sustainability in Community Based Disaster Management. The approach taken in these projects reflects the ideology and attitude of PAR. CBDM promotes a bottom-up approach where the strengths of communities are recognized and built upon. Just as in PAR, community empowerment is fostered through participation in all stages of disaster planning, including assessment, implementation, and maintenance. One of their CBDM initiatives took place after the 2001 earthquake in Gujarat, India in a village called Patanka. The post-earthquake rehabilitation project successfully integrated the livelihood of the village by training and empowering local communities with "earthquake safer technologies" (Pandey and Okazaki 2005).

b. Traditional ecological knowledge

By focusing on the local cultures and knowledge of the Patanka village, UNCRD integrated the traditional ecological knowledge (TEK) of the community. The following provides a definition of TEK provided by Berkes (2000):

…a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings with one another and with their environment.

Table 2 presents various benefits and limitations of using TEK in the field of disasters and natural hazards. Despite the shortcomings of utilizing TEK, the positive outcomes of its integration vastly outweigh the negative. Without recognition and respect for a local community's knowledge, the sustainability and appropriateness of any disaster management plans cannot be guaranteed (Dekens 2007).

CHAPTER III. RESEARCH OBJECTIVES, HYPOTHESES, AND METHODOLOGY

Research Objectives and Hypotheses

The overarching research objective for the present study is to investigate the current risk perceptions, place attachment, and adaptation preferences of south Terrebonne Parish residents in order to understand the potential role of a community-centered mobile application on future climate change adaptation. Our work involves the simultaneous execution of two data collection methodologies. First, data regarding risk perception, place attachment, and adaptation preferences was collected using a 34-question close-ended survey. Analysis of survey responses was designed to test the following hypotheses:

1. Residents of south Terrebonne Parish are aware of the coastal hazard of land loss.
2. Proactive climate change adaptation is positively influenced by a residents' risk perception to land loss.
3. Proactive climate change adaptation is negatively influenced by residents' strong place attachment.

Second, the PAR methodology was adopted to create the community-centered land loss awareness application called *Vanishing Points*™. An investigation on the implications of *Vanishing Points*™ on future adaptation preferences and practices was guided by the following questions:

- What are the advantages and disadvantages of participatory action research in the context of climate change compared to the conventional methodologies of gathering information?

- How can the information presented in *Vanishing Points™* impact an individual's place attachment and risk perception?
- What are the potential effects of *Vanishing Points*™, if any, on adaptation preferences and practices?

Data Collection

a. South Terrebonne Parish survey

A 34-question survey was created for random distribution during the months of June – August 2013 using the online survey software Qualtrics. The design of the survey featured various types of questions: single-answer multiple choice, multiple-answer multiple choice, dichotomous yes/no, and 5-point Likert scale (e.g., strongly disagree to strongly agree). All survey items were close-ended where eleven multiple-answer multiple choice questions provided respondents with the option of "Other, please specify." The survey (Appendix A) is divided into five parts that focus on personal and community insights of the following topics:

- Part 1: Connection to environment and impacts of land loss
- Part 2: Land restoration
- Part 3: Climate change and sea level rise
- Part 4: Past extreme weather event experiences
- Part 5: Basic demographic information

Part 1 included questions targeted towards residents' place attachment by asking about their feelings towards the natural surrounding environment. This part additionally

included questions about the physical impacts of land loss in their community in order to gauge residents' risk perception. Part 2 addressed the plausibility of one future adaptation option for south Terrebonne residents – restoration. Similar to Part 1, Part 3 contained questions regarding the physical impacts of climate change and sea level rise as well as how these impacts may be affecting their connection to the surrounding environment. Part 3 also inquired about possible constraints, at an individual and community level, that are faced in climate change preparation and adaptation. While Part 3 focuses on future adaptation, Part 4 investigated past adaptation practices and experiences with extreme weather, particularly tropical storms and hurricanes. Finally Part 5 collected basic demographic information such as age, length of residency in Terrebonne Parish, and income.

Prior to distribution, a pilot study period occurred from 1 June – 15 June 2013. During this time, face-to-face administration of the survey with key informants (i.e. community leaders, Native-American chiefs, NGO directors, etc) allowed for instantaneous feedback on the survey questions. Resident correspondence also brought to light several barriers that would influence the method of survey distribution. One, the residents have limited computer access. As indicated by several key informants, the high frequency of flooding and tropical storm damage has resulted in the preferred use of smart phones over personal home computers to reduce replacement costs. A second issue is the presence of language barriers because of the cultural preference of speaking the native language of Cajun French (Brasseaux 1992). Finally, low literacy levels are present. Only 13.8% ± 1.1% of Terrebonne Parish's population has an education attainment of a bachelor's degree or higher (Census 2010). As a result of these barriers, it

was determined that face-to-face administration was the most effective method of survey distribution.

A total number of 125 responses was collected from 16 June to 3 August. Figure 5 illustrates the distribution of completed surveys throughout the communities of south Terrebonne Parish. Of these 125 surveys, 31 residents responded to email (see Appendix B) and newspaper (Buskey 2013) recruitments and completed the survey on Qualtrics. The average response time of these respondents was about fourteen minutes. Any survey questions skipped by these respondents resulted in a reduced number of observations for various survey items as indicated in the following section. The remaining 94 surveys were administered in-person. A total of 450 surveys were distributed by selecting homes at random throughout the different communities. Through this method, each survey took an average of two and a half hours to complete. The significant discrepancy in response time can be attributed to human interaction and resulting conversation during survey administration. Surveys were additionally distributed at community gathering places (e.g., churches, libraries, community centers, and fishery docks). Assistance was also provided by the various volunteer fire departments serving these communities. Supplementary to their participation, the vast social networks of these service men and women proved to be vital in distributing surveys to local businesses.

1) MEASURES OF ADAPTATION

Within the survey, several themes arise that represent various factors that may impact residents' adaptation practices. Below provides a description of all the survey

items of interest that fall under the following themes: risk perception, place attachment, and adaptation preferences.

(i) Risk Perception

The survey questions and variable names used to measure risk perception, place attachment, and adaptation are highlighted in Table 3. Measures of risk perception were gathered through survey questions pertaining to the impacts of land loss and climate change, past tropical storm or hurricane experiences, and future vulnerability to extreme weather. To measure perception of land loss and climate change, residents were asked, "When do you think your community will start feeling the effects of land loss?" Respondents were given the following choices: we are already feeling the effects; in the next 10 years; in the next 25 years; in the next 50 years; in the next 100 years; beyond the next 100 years; never. These responses were recoded to form the dichotomous responses of (1) yes, the effects of land loss are currently seen or (0) no, the effects are currently not seen. An additional survey question asked residents, "Do you think you are sufficiently informed about the current and future impacts of climate change and sea level rise?" with the response choices of (1) yes or (0) no. In order to determine residents' past experience with tropical storms, respondents were asked to identify the storms they experienced from a list of ten tropical storms and hurricanes that have made landfall in Louisiana within the past 10 years (Roth 2010). As a follow-up question, respondents were additionally asked if any of the storms experienced caused any property damage. Respondent perception to extreme weather vulnerability was measured through two questions. First, residents were asked to identify changes in their community related to

climate change and sea level rise. On the list appeared "Higher frequency and intensity of extreme weather events" where its selection translated to a (1) yes or (2) no dichotomous question. Second, residents were additionally asked, "How vulnerable do you think your community is to extreme weather events (hurricanes and floods) in the next 10 years?" Responses were scaled on a 5-point Likert scale ranging from (1) not at all to (5) a great deal.

(ii) Place attachment

Several survey questions provided the basis of measuring place attachment by asking respondents about their quality of life and connection to the land. On a 5-point Likert scale ranging from (1) strong disagree to (5) strongly agree, residents were asked to rate their feelings on the following two statements: climate change and sea level rise are threatening my quality of life; I feel as if I'm losing my connection with the land because of the impacts of climate change and sea level rise. Responses ranging from (1) strongly disagree to (4) tend to agree and responses of (5) strongly agree were recoded to reflect a binary response of (0) no or (1) yes, respectively.

(iii) Adaptation preferences and practices

Measures of residents' adaptation preferences resulted from survey questions regarding their past actions to tropical storm or hurricane threats, current thoughts about climate change preparation, and prospects of future community abandonment and restoration. From the list of landfalling storms described previously, respondents were asked to indicate whether or not they evacuated for the storms they experienced. The total

number of evacuations was calculated for each respondent and expressed as a continuous numerical value. With regards to climate change adaptation, respondents were asked to identify any constraints that inhibit taking preparatory action for the impacts of climate change and sea level rise. At an individual level, two options provided were "I don't think it's worth it" and "It's too expensive". At the community level, one of the statements provided was "Lack of leadership and direction". Selection of these statements was translated to a binary response of (1) yes that indicated the respondent's affirmation in the statement(s). Subsequently, residents were asked how useful a mobile application would be for providing climate change adaptation information where responses ranged from (1) not useful at all to (5) very useful. The likelihood of community abandonment was measured on a 5-point Likert scale ranging from (1) very unlikely to (2) highly likely for the question "In your opinion, how likely is it your community will have to be abandoned by 2050 due to land loss?" Finally, residents were asked, "Do you believe that the coastal wetlands of south Terrebonne Parish can be successfully restored?" to which their responses were either (0) no or (1) yes.

(iv) Additional measures: socio-demographics

The sociodemographic information gathered included gender, age, occupation, income, household size, length of residency in south Terrebonne Parish, and extreme weather vulnerability factors such as elderly or children present in a household (Cutter et al. 2003).

b. Vanishing Points^{TM} – community-centered mobile application

The idea of creating a land loss awareness mobile application that showcased the impacts of sea level rise and land subsidence was proposed by a community member by the name of Jonathan Foret. He is currently the Executive Director of the South Louisiana Wetlands Discovery Center (SLWDC), a local organization serving to increase land loss awareness and ensure the security of future generations by educating the youth of southern Louisiana with the necessary skills and knowledge for adapting to their changing environment. Born and raised in south Terrebonne Parish, Jonathan has witnessed the impacts of land loss. Armed with his experience and knowledge, Jonathan carries a passion of educating his people in hopes of saving the culture and livelihood of south Terrebonne's communities.

The SLWDC plays an essential role of increasing the community's willingness to adapt; however, the responsibility of doing such cannot fully fall on a single organization. There must be a collective effort where land loss awareness spans from the youth of the local communities to the citizens of our nation. Currently, the most common tool used to inform others about the extreme land loss are maps and illustrations similar to Figure 6. Such images are effective in portraying the geographic changes; on the other hand, these maps are incapable of educating individuals about the subsequent socio-cultural changes and impacts. As a result, the question was posed: How can we increase awareness and recognition of the impacts of land loss, especially on the culture of south Terrebonne?

Given the traditional nature of south Terrebonne, cultural knowledge is transmitted primarily in the form of oral story-telling. The stories told date back to the times of their ancestors that settled on the same lands three generations ago. Stories about

the agricultural pastures starkly contrast the vast landscapes of open water and wetlands seen today. Consequently, it was realized that these stories should be used to showcase the effects of land loss on culture. As suggested by Jonathan Foret, utilizing mobile technology could serve as an influential communication and educational medium to broadcast the voices and experiences of these communities. Building upon this idea resulted in the development of a mobile application called *Vanishing Points*™. The objective was to collaborate with the communities of south Terrebonne to create a land loss awareness application that highlighted culturally significant locations in order to increase local and national attention to their disappearing land.

The data collected for *Vanishing Points*™ occurred during the months June to August in 2012 and 2013. The six month time frame resulted in the generation of an extensive qualitative database comprised of recorded interviews and transcribed conversations that were not tape-recorded. The data desired for *Vanishing Points*™ were the following: identification of culturally significant locations, oral history of location, historical and current pictures, video testimonies, and geographic data. All the data collected (excluding geographic data) came directly from the community members. As per PAR, *Vanishing Points*™ allows the people to tell their story regarding the impacts of land loss according to them, in a way that they understand.

1) IDENTIFICATION AND DOCUMENTATION OF ORAL HISTORY

As a conversation starter, community members were asked the following question: What places in your community hold deep meaning to you and/or your family? Follow up questions included: What makes [the specified location] so special? How long

has this location existed? Are there any stories that have been passed down about this location? Could you describe some of the changes you have personally seen at this location? As conversations progressed, an oral history of the location(s) was obtained and tape-recorded (with granted permission). A location was confirmed as significant if validated by three or more community members. The recorded data was used to write a short description for each location.

2) HISTORICAL AND CURRENT PICTURES

The purpose of collecting historical pictures was to provide users of *Vanishing Points*™ with ground-based images demonstrating the dramatic land changes between the past and present. During conversations, community members were asked if they possessed historical pictures that they were willing to share with the potential users of the application. For each picture, requested information included the date, location, short description, and pseudonym for photo accreditation. For each location, one present-day picture was taken at the same location as the historical picture to create a before-after pair. Ten present and ten historical pictures were collected for each vanishing point.

3) VIDEO TESTIMONIES

The oral histories of each vanishing point served a dual purpose. As previously described, guided conversations lead to the composition of short descriptions for each location. Such conversations were also used to determine which individuals in the community had the most historical knowledge and personal attachment to each vanishing point. Results of these conversations lead to identification of Native American chiefs,

well-respected elders, owners and/or managers, etc. The guiding conversation questions previously discussed were also presented to these individuals. Following the conversation, individuals were asked if their responses to the discussed questions could be video recorded. If he/she wished not to do so, alternative individuals were recommended. If the community members wished to proceed with the recording, the same guiding questions were again asked. The purpose of repeating the same conversation questions during recording was to give individuals adequate preparation in order to decrease any anxiety of being recorded.

4) GEOGRAPHIC DATA

The following geographic data was collected for each vanishing point: ground elevation, GPS location, advisory base flood elevation (ABFE), and the elevation to pass FEMA standards (EPFS). Handheld GPS units used at each location provided accurate ground elevation and GPS data in feet and mixed minutes/decimal format (e.g., N 29°24'24.45 W 90°29'29.44), respectively. The ABFE was obtained using an interactive flood mapping interface provided by the Louisiana State University Agricultural Center (i.e. http://maps.lsuagcenter.com /la_floodmaps/?FIPS=22109). Finally, calculation of the EPFS involved subtracting the ground elevation level from the ABFE.

CHAPTER IV. DATA ANALYSIS AND FINDINGS

As previously stated, our study adopted a multidisciplinary approach that involved the collection of data through 1) online and in-person survey, and 2) participatory action research methodology. As such, the chapter first presents basic survey response statistics followed by probit and bivariate probit estimation regression models of adaptation. The second part of the chapter provides an account detailing the result of adopting PAR in south Terrebonne Parish, a description of the mobile application platform, and community responses to the application.

Survey Results

To summarize the social demographic results, 39% of the respondents are male and have spent an average of 39 years living in south Terrebonne Parish. The mean age is between 35 and 54 years of age where the majority (24%) fall within the age group of 45 to 54 years old. With an average household size of 3.25, 18% of the households have individual(s) over the age of 65 years old and 34% with individual(s) under the age of 18 years old. The average annual income of respondents is between $25,000 and $34,000. Excluding the 14% of respondents that are retired, the predominant occupations represented in the population sample are the following: non-profit/service/community work (19%), administration (16%), education (14%), and agriculture (e.g., fisherman – 12%).

a. Risk perceptions in south Terrebonne Parish

At a scientific level, southern Louisiana currently faces detrimental coastal impacts from land loss and climate change. At the community level, these impacts are also evident to the majority of south Terrebonne Parish residents. Ninety-three percent of 124 respondents acknowledged that their community is currently feeling the effects of land loss. Residents are also aware of the impact of climate change on extreme weather. Over half (66%) of all 125 respondents recognized an increase of frequency and intensity of extreme weather. Additionally, the average ranking of vulnerability to extreme weather events in the next ten years on a 5-point Likert scale ranging from 'not at all' to 'a great deal' was a 4.8. This can be attributed to the residents' past experiences with tropical storms and resulting floods (Dow and Cutter 2000, Weinstein 1989). Out of the ten storms that have made landfall in Louisiana within the past ten years, residents have experienced an average of 6.6 storms. Of those storms, the majority of these 122 respondents (85%) received property damage. Despite the indicated local awareness, over half (69%) of 115 respondents do not feel they are sufficiently informed about the current and future impacts.

b. Place attachment

As described by Burley (2010), the residents of coastal Louisiana have a strong connection to place and thus an emotional bond to their land resulting from interactions with it. The connection to the land was made apparent by the 79 of 124 respondents that strongly agreed with the statement "I feel that I share a bond with the things in the natural environment around me." However, the current changes of their environment and the

ecosystem they rely on for natural resources is undergoing change that can create a sense of loss (Doherty et al. 2011). About half (47%) of respondents strongly agree that their connection with the land is currently being lost with about the same proportion of residents (48%) that strongly agree that climate change and sea level rise is threatening their quality of life.

c. Past, present, and future adaptation preferences and practices

As previously mentioned, the residents of coastal Louisiana have been impacted by ten tropical storms and hurricanes within the past ten years (Roth 2010). Within the past ten years, the average number of evacuations for all 125 respondents was two times. Although residents have been well-seasoned with regards to extreme weather, about 55 out of 123 respondents reported it is very likely that their community will have to be abandoned by 2050 (Figure 7). On the other hand, about 76% of the residents believe that the coastal wetlands of south Terrebonne Parish can be successfully restored (Figure 8). This finding is supported by the positive response of 125 residents that believe it is worth it to prepare for the impacts of climate change and sea level rise. Over half (62%) of these respondents feel that climate change preparation is too expensive. About 53 out of 119 residents think that a mobile application would be very useful in providing adaptation information – a positive finding for the beneficial use of *Vanishing Points*™. Finally, about 59% of all 125 respondents feet there is a lack of leadership and direction in their community – a necessary component needed to combat climate change related loss (Randall 2009).

1) INFLUENCE OF PLACE ATTACHMENT AND RISK PERCEPTION ON ADAPTATION

The two adaptation preferences presented above represent all three climate change adaptation options designated by the IPCC (2001). Abandonment of their community by 2050 and successful restoration of the coastal wetlands reflects the pursuit of retreat and the desire of accommodation and/or protection, respectively. These adaptation variables *Abandon* and *Restore* involve risk-based decision making that is influenced by a residents' risk perception and place attachment (Burley 2010, Grothmann and Patt 2003).

In order to test Hypothesis 2, that proactive climate change adaptation is positively influenced by a residents' risk perception to land loss, and Hypothesis 3, that proactive climate change adaptation is negatively influenced by residents' strong place attachment, the binary logistic regression approach was utilized to estimate the probability of a resident's decision to retreat as well as accommodate and protect. The binary logistic model (Long and Freese 2006) is as follows:

$$Y_i^* = \beta_1 X_i + \gamma_i \qquad (1)$$

where β_1 is the coefficient of the predictor values, γ_i is an unknown scalar, and, Y_i^* is a latent variable and Y_1 is the dichotomous variable *Restore* observed as:

$$Y_{1i} = \begin{cases} 0 \; if \; Y_{1i}^* < 0 \\ 1 \; if \; Y_{1i}^* \geq 0 \end{cases} \qquad (2)$$

The variable Y_2 (*Abandon)* is observed on a 5-point Likert scale and is modeled using a binary ordered logistic model that follows Eq. (1) but described as:

$$Y_{2i} = \begin{cases} 0 \; if \; Y_{2i}^{*} < 0 \\ 1 \; if \; 0 \le Y_{2i}^{*} < 1 \\ 2 \; if \; 1 \le Y_{2i}^{*} < 2 \\ 3 \; if \; 2 \le Y_{2i}^{*} < 3 \\ 4 \; if \; 3 \le Y_{2i}^{*} < 4 \\ 5 \; if \; 4 \le Y_{2i}^{*} < 5 \end{cases} \tag{3}$$

The algorithm used by STATA 10 to produce these models follows a standard logistic distribution with mean zero and variance $\frac{\pi^2}{3}$ constructed by an iterative maximum likelihood procedure where the log likelihood function for *n* independent observations is as follows:

$$\log L(\beta) = \Sigma\{Y_{li} \log(\pi_i) + (n_i - Y_{li}) \log(1 - \pi_i) \tag{4}$$

where $l = 1,2$ and π_i is the underlying probability for data $n_i = 1$ for all *i*.

Pseudo R^2s of the binary logistic models were also calculated by STATA 10 as per McFadden's formula shown below:

$$R^2 = 1 - \frac{\ln \hat{L}(M_{Full})}{\ln \hat{L}(M_{\text{int}ercept})} \tag{5}$$

where the log likelihood $\hat{L}$ of the intercept model $M_{\text{int}ercept}$ is the total sum of squares while the log likelihood of the full model M_{Full} is calculation from the sum of the squared errors.

Although logistic estimations are commonly used to analyze dichotomous and other categorical choice variables, we recognized the potential bias of factors that are co-dependent on a resident's adaptation preference. For example, a resident who feels that it is not worth preparing for climate change (*Notworth)* may not think optimistically about

their community's survival, thus favoring the high likelihood of community abandonment. Additionally, if a resident feels their quality of life is threatened (*Threat*), there may be a similar lack of optimism towards successful future wetland restoration. The recognized nature of these endogenous variables and consequent application of bivariate probit estimations follows the technique used by Mozumder et al. (2009) who analyzed residents living in the wildland urban interface and their willingness to pay for a wildfire risk map. Using the seemingly unrelated option in STATA 10, the bivariate probit model (Ratnasari et. al 2011) can be described as:

$$\begin{aligned} Y_{li}^{*} &= \beta_1 X_{1i} + \varepsilon_{1i} \\ Y_{li}^{*} &= \beta_2 X_{2i} + \gamma Y_{l}^{*} + \varepsilon_{2i} \end{aligned} \tag{6}$$

where l = 1,2,3,4, β_1 and β_2 are the coefficients of the predictor values, ε_{1i} and ε_{2i} are error terms, γ is an unknown scalar, Y_{li}^{*} are latent variables, and Y_{1i} *(Restore)* and Y_{2i} *(Threat)* are dichotomous variables observed as:

$$Y_{1i} = \begin{cases} 0 \; if \; Y_{1i}^{*} < 0 \\ 1 \; if \; Y_{1i}^{*} \geq 0 \end{cases} \tag{7}$$

The ordered categorical variable Y_{3i} (*Abandon)* and dichotomous variable Y_{4i} (*Notworth)* were jointly estimated by applying the bivariate ordered probit approach which uses the system found in Eq. (6). The two variables Y_{3i} and Y_{4i} were observed such that they followed Eq. (2) and Eq. (3), respectively.

(i) Models for Abandon

Ordered logistic estimates of the likelihood of community abandonment are reported in Table 4. In Models 1 and 2, the threat of climate change and sea level rise on the quality of a resident's life (*Threat*) is highly significantly related (at the 1% levels) to how likely a resident thinks their community will have to be abandoned by 2050 (*Abandon*). This implies that individuals who feel the negative impacts of climate change on the various aspects of their lives have a higher probability of adapting by retreat. Other explanatory variables that affect a respondent's preference to retreat (*Abandon)* involve their perception to the impacts of land loss and climate change. Seeing a decrease of vegetation in the past ten years due to land loss (*Vegetation*) is found positively significant at the 10% levels (in Model 1). Additionally, a resident that currently feels the effects of land loss in their community (*Landloss*) and recognizes the high vulnerability of extreme weather events in the next ten years (*Vulnerable*) has a significant higher likelihood (at 1% levels in Model 2) of abandoning their community by the year 2050. Acknowledging the increase of intensity and frequency of extreme weather events due to climate change (*Weather)* is negative and statistically significant at 5% levels to the likelihood of retreat (Model 1). This implies that an increase of hurricane and flooding does not have in impact on a resident's likelihood of abandonment. As for the control variables found in Models 1 and 2, past tropical and/or hurricane property damage (*Damage*), size of a household (*Household*), and gender (*Gender*) are insignificant and positive while annual income (*Income*) is also insignificant yet negative. The control variable that does have a significant contribution (at 1% and 5% levels) is the number of evacuations within the past 10 years (*Evacuation*).

The endogenous variable in Model 2, *Notworth,* is found highly significant at 1% levels. Residents who feel it is not worth preparing for climate change impacts have a higher likelihood of retreating. However, the worthiness a respondent places on climate change adaptation can be further explained by other variables. As a result, application of the bivariate ordered probit approach allowed the addition of a separate equation that included factors that can affect a resident's decision about the worthiness of climate change preparation. Bivariate probit estimations are reported in Table 5. The estimations and significance of the various factors influencing a resident's decision about community abandonment (*Abandon*) for Models 5 and 6 are consistent with the results found in Model 2 (Table 4). The variable *Notworth* remains statistically significant (at 5% and 10% levels). Residents that have seen land loss in their communities (*Landloss*), recognize the high vulnerability of extreme weather events in the next ten years (*Vulnerable*), and feel their quality of life is threatened (*Threat*) also remain positive and highly significant at 1% and 5% levels. The control variables *Household* and *Gender* are consistently insignificant and positive. Similarly, annual income *(Income*) remains negative and insignificant. In Model 5 however, past tropical storm/hurricane property damage (*Damage*) positively contributes (at 10% levels) to a resident's preference of retreat.

With regards to the bivariate ordered estimation of the second dependent variable *Notworth,* respondents that feel it is too expensive to prepare for climate change (*Tooexpensive*) is highly significant at 5% levels in Model 5 and 6. The seemingly high cost of climate change deters residents from thinking climate change adaptation is worth it. Another statistically significant explanatory variable (at 5% levels) found in Models 5

and 6 is *Elderly,* residents that have one or more individuals over the age of 65 living in their household. The presence of elderly individuals tends to negatively contribute to the respondents perception of the worthiness of preparation. It is possible that the presence of older individuals makes the decision to retreat more difficult for reasons further discussed in Chapter 5. The influence of residents who work in the agriculture industry (*Agriculture*) is positive and highly significant to the worth of climate change preparation (at 1% levels in Model 6). A possible implication is that residents with occupations that involve interaction with the environment have witnessed and endured the impacts of land loss and climate change; thus, possibly gaining a realistic yet pessimistic perspective on the worthiness of preparation. Additionally, respondents who think the use of a mobile application to provide climate change information (*Mobileapp*) have an increased likelihood thinking it is not worth to prepare (at 10% levels in Model 6). This is indicative of the lack of climate related information residents receive in order to make informed adaptation decisions. It is possible that *Vanishing Points*™ can provide communities with such information. In Models 5 and 6, residents who think it is not worth to prepare are negatively influenced by the two control variables gender (*Gender)* and annual income (*Income*). Their decision is also positively influenced by years of residence in south Terrebonne Parish (*Residency*).

(ii) Models for restore

Logistic estimations of the probability that a resident supports the wetland restoration is reported in Table 6. Similar to the factors that affect the likelihood of a resident preferring community abandonment (*Abandon*), residents who think that the

coastal wetlands of south Terrebonne Parish can be successfully restored (*Restore*) is affected by the variables *Notworth* and *Threat* (Models 3 and 4). Respondents that do not think it is worth preparing for climate change (*Notworth*) have a significantly higher likelihood (at 1% levels) of rejecting the possibility of future successful wetland restoration (*Restore*) is possible. Residents that do not think it is worth preparing for climate change impacts do not support the adaptation options of accommodation and/or protection. Similarly, it was found that the threat of climate change on a respondent's quality of life (*Threat*) has a negative contribution (significant at 1% and 5% levels in Models 3 and 4, respectively). This implies that place attachment has an influence on a resident's preference to retreat as well as accommodate and/or protect. In Model 4, the lack of leadership in a resident's community (*Noleadership*) was identified as a constraint to climate change preparation. Although the impacts are insignificant to the likelihood of supporting successful restoration (*Restore*), results showed that this factor has a negative contribution that is worthy of noting. Without well-established leadership in a community, it is difficult for residents to believe that their coastal wetlands can be restored. There is one control variable that is negative and significant at 10% levels in Model 3 – *Gender*. All other control variables found in Models 3 and 4 are insignificant and have no effect on a resident's support of successful wetland restoration: household size (*Household*), annual income (*Income*), and number of evacuations in the past 10 years (*Evacuation*). Occupational controls were also included in Models 3 and 4 to account for residents that may be more informed about successful restoration – those in the scientific field (*Science*) and those who work in nonprofit organizations (*Nonprofit*).

Neither of these variables showed to have a significant effect on a respondent's support of successful restoration.

In the same way that a resident's worth on climate change adaptation (*Notworth*) was treated as an endogenous variable for modeling the adaptation preference of retreat (*Abandon*), the threat of climate change on a resident's quality of life (*Threat*) was considered as an endogenous factor that influenced the support of successful wetland restoration (*Restore*). Therefore, bivariate probit probabilities of *Restore* were jointly estimated with the variable (*Threat*) and reported in Table 7. Consistent with the estimate probabilities in Models 3 and 4, *Threat* remained negative and significant (at 1% levels) in Models 7 and 8. The support of successful wetland restoration (*Restore*) is again negatively influenced (significant at 10% and 1% levels in Models 7 and 8, respectively) by residents who feel it is not worth to prepare for climate change impacts (*Notworth*). The lack of climate change preparatory leadership in a community (*Noleadership*) is also consistent with previous results – the variable is insignificant and negative. With regards to the control variables, the coefficient estimations for *Household, Evacuation,* and *Nonprofit* remains consistent with those found in Models 3 and 4. *Gender* is negative and significant at 1% levels in Model 8. The other control variables *Income* and *Science* became statistically significant at 1% and 5% levels in Models 7 and 8. After consideration of a resident's place attachment, annual income and those who work in the scientific field turned out to be influential factors on supporting successful wetland restoration.

As reported in Table 7, the significant factors that affect whether or not a respondent feels that their quality of life is threatened (*Threat*) includes the variable

Noleadership (significant at 1% levels in Model 8). Residents who see a lack of leadership in their community as a constraint to climate change adaptation (*Noleadership*) feel threatened by the impacts of climate change. In Models 7 and 8, respondents that are ill-informed about the current and future impacts of climate change (*Informed*) also have a higher likelihood of feeling threatened (at 5% and 10% levels). Respondents who currently have an occupation in the field of agriculture (*Agriculture*) leads to a higher probability (at 1% levels in Model 7) of feeling that their quality of life is threatened. This implies that the impacts of climate change on the environment are also having impacts on resident's occupations that ultimately influence attachment to place. In fact, the residents who feel that they are losing their connection with the environment (*Connection*) have a significantly higher likelihood (at 1% levels in Model 8) of being threatened by climate change impacts. With regards to the following control variables in Models 7 and 8, none have a significant influence on the endogenous variable *Threat*: years of residence in south Terrebonne Parish (*Residency*), presence of individuals under eighteen years old in the household (*Children*), respondents with the age that falls in between 35 and 54 years old (*Middle*), gender (*Gender)*, and annual income (*Income*).

Vanishing Points™ Results

a. PAR in south Terrebonne Parish

Integration and acceptance into the communities of south Terrebonne was one of the first barriers that had to be conquered before any data was collected. The validation process lasted two weeks, a relatively short time because of the relationships created with individuals who had established rapport (Park 1993) in the community (e.g., community

leaders, social scientists who previously conducted research in the area). Additionally, trust was fostered through an enthusiasm for cultural emersion through activities such as shrimp trawling, attending community functions, and spending time with community members. During participation in these activities, it quickly became evident that the residents of south Terrebonne had little trust in scientists and researchers. One community member stated:

How can you even begin to tell us anything at all when you have not come down here? They look at us from a map. You have to get in it and talk to the people who have been here for 40+ years. Come get on a boat and we will educate you! This information is not in a book.

This prevailing attitude created an understandable hesitation to invest their time in the study. Yet, upon disclosure of the intent to collaborate with the communities, the idea of developing a product that can help broadcast their voices became widely accepted.

During the collection of the various content pieces, the barrier of time was also encountered. In order to avoid any inconveniences to the community members, research had to be completed within the schedules of the community members. In addition, guided conversations lasted hours at time and resulted in the laborious process of extracting relevant data. Despite these obstacles, the participatory development of *Vanishing Points*™ fostered beneficial outcomes such as ownership of a project and community empowerment. Collaboration allowed the residents to feel that the knowledge and experiences they held are indeed valuable in the eyes of a researcher.

b. Vanishing Points™ platform

A functioning platform for the application was created by the collaborative efforts of several individuals from UCAR, especially that of Ryan McVeigh and Randy Russell. After creating a wireframe for *Vanishing Points*™, Word Press was used to construct and publish a website optimized for mobile use (i.e. smart phones, tablets). *Vanishing Points*™ features a Google Map interface that identifies the various culturally significant locations. Upon selection of a vanishing point, the user accesses the aforementioned content pieces (e.g., historical pictures, video testimony) seen in Figure 9.

c. Community response

As part of the PAR process, it is important to have the project results validated by the local people. As such, several meetings were held with community members and local stakeholders in order to verify that the information presented in *Vanishing Points*™ correctly reflected the local culture and knowledge. For each meeting, a short presentation of the application was delivered followed by open discussion. The overall response to the application was overwhelmingly positive. The local people felt that it was *"something good to have"* so that *"everyone could see what's happening"* in south Terrebonne. They acknowledged that the application could help them *"connect to people in the other states"* where it could be *"one more way to get the people involved"*. A striking reaction shared by the several elders was that *Vanishing Points*™ *"is not good for the older generation"* yet it is a way *"for the young people to be helped – they don't know their peril"*. The application will allow the younger generation to be *"in touch with their reality"*. Consequently, we intend to use the application as a cultural and

educational tool. High school students will be trained on how adopt PAR methodology to obtain data for the various content pieces of *Vanishing Points*™. Doing so will foster intergenerational transmission of cultural knowledge. The students will also be trained on how to upload the collected data into Word Press.

During these meetings, community members additionally identified features that could make *Vanishing Points*™ more effective and useful. If users were to use the application more than once, community members suggested making the application more interactive by including the following features: ability to submit and upload pictures, Facebook, Foursquare, and/or Twitter integration; weather and marine forecasts; community announcement and/or meeting board; and tropical storm advisory board. Further development of the application will consider these suggestions based on feasibility.

CHAPTER V. DISCUSSION AND CONCLUSIONS

The residents of south Terrebonne Parish face extreme land loss, a perpetual natural disaster that will exacerbate due the impacts of climate change. From the years 1932 to 2010, Louisiana has lost about 25% of its land mass (Couvillion et al. 2011) due to several factors such as the oil and gas industry and levee construction of the Mississippi River. With the additional impacts of relative sea level rise, the residents of coastal Terrebonne Parish are called to adapt to the stark changes of their land. For centuries, these communities have been living a lifestyle that involves living off the land. Their years of personal interactions with the environment uniquely impact current and future adaptation practices because of the gained connection to place and unique perspectives on land loss (Burley 2010). Through regression modeling, it was determined that these two factors, place attachment and risk perceptions, have a significant effect on adaptation practices and preferences. In order for adaptive management and planning to be effective, we must start considering these factors at an individual and communal level.

The residents of south Terrebonne Parish pride themselves in having a unique culture, rooted in generations of working in the industries of sugar cane, timber, oil and gas, and especially seafood (Austin 2006, Gould 1984, Woodman 1979). They have been able to preserve their culture not solely though passage of oral histories, but by continuing to live in the ways of their ancestors. Termed "narrative continuity" by Higgs (2003), the communities in this study hold a strong connection to place because of their current lifestyles that were established centuries ago. However, the impacts of land loss have damaged the physical environment in which these lifestyles originate, causing injury

to self (Burley 2010). As concluded by a study regarding place-identity on the Sunshine Coast of Australia, Carter et al. (2007) emphasizes the examination of physical environment degradation and its impact on place attachment. If it is not examined, then intuitively there can be a substantial amount degradation without having any impacts on attachment and ultimately adaptation preferences and practices. As indicated by our regression results, residents do in fact feel that their quality of life is being threatened by climate change and sea level rise. The threat can cause "solastalgia", or the sense of being distressed because of the negative transformation of their land (Albrecht et al. 2007). Overall, there are significant impacts of this threat on adaptation preferences of retreat and protection. Those who feel threatened are less likely to think the coastal wetlands can be restored and abandon their communities. This is especially true for residents who currently hold an occupation in agriculture. Fisherman and farmers, for example, depend on the coastal environment where any damage to the environment threatens an important quality of their lives – job security (Burley 2010). Years in the industry enable them to be first-person witnesses to the progression of the disappearing coast.

Not only are fisherman and farmers directly impacted by land loss, all community residents are also more likely to acknowledge the impacts of land loss because of their continuous interaction with the environment. A resident that currently feels the impacts of land loss in their community has a significantly higher likelihood of abandoning their community. As reported in Table 8, we observed that those who currently see land loss and stated that community abandonment is "highly likely" is close to what is expected. Residents additionally recognize the decrease of vegetation as a recognizable impact of land loss as described by a resident in the community Chauvin:

When it [Bayou Terrebonne] ended, there used to be the biggest live oak trees. There were close to thousands of live oaks along that bayou that wend down for about 7-8 miles. The oak trees lined the bayou and off the bayou for about several hundred fee. I can remember parking a boat when I was kid, 40 years ago…big deep tall gorgeous grass, green grass, with these big oak trees. Today you can't even tell they'd be stumps of these trees. Every now and then you will see a stump of where one of these trees existed.

With regards to climate change impacts, residents have a significant recognition of the vulnerability to extreme weather events in the next ten years as well as the increasing frequency and intensity of extreme weather events. The recognition of vulnerability to extreme weather increases the likelihood that a resident will abandon their community. On the other hand, the opposite is true for the increase of extreme weather. The significantly negative impact on abandonment can be attributed to residents being accustomed to extreme weather. The prospects of experiencing more hurricanes and extreme flooding may not faze the residents of south Terrebonne Parish because of their long history of dealing with such natural hazards. As described by a Dulac resident: *We deal with hurricanes on a regular basis…We're born into this. The minute you spray the mud out of your house, you're cutting the wall and you're rebuilding. We do this like it's the normal thing to do and then we go on about our lives. It doesn't stop us in any way. And we don't have loss of life.*

Similarly, residents who tend to frequently evacuate are also more likely to emanate similar behavior for climate change adaptation through community abandonment, supporting the finding that past experience is an important factor in response (Dow and Cutter 2000).

Resident preferences of future adaptation are also significantly influenced by the worth they place on preparing for climate change. For the small population of residents that feel it is not worth preparing, they are more likely to abandon their community. However, the majority of residents do think it is worth preparing for climate change as seen in Table 10. This can be indicative of the optimistic views about successful future restoration. Alternatively, residents of south Terrebonne Parish can be avoiding the adaptation option of retreat possibly because of anxiety and worry (Doherty and Clayton 2011) about leaving their home. As voiced by many residents during the course of interviews and survey distribution, there is great concern about the impacts of retreat on the cultures of these communities.

If the land washes away, we want to move as a community. Because if they move us individually, they have just completely annihilated our tribes. No more culture, no more heritage, it's all gone. It's good to adapt, but not when it's the cost of your own.

There are also social demographics that significantly influence the preference of protection. Similar to residents that work in the agriculture industry, holding an occupation in the scientific field has a significant impact on the perception of coastal wetland restoration. These residents are more likely to have a deeper understanding of the factors involved in restoration, thus disputing successful restoration. In the same way, results indicated that income had a significant impact on a residents' restoration perceptions. This can be attributable to the corresponding higher sense of awareness as a consequence of the higher education level necessary to attain higher paying jobs. The presence of individuals over the age of 65 additionally has a significant influence on adaptation preference. Households with elderly individuals are less likely to abandon

their communities. Comparable to hurricane vulnerability, presence of the elderly brings forth issues of mobility, accommodation, and caretaking capabilities (Ngo 2001). Finally, there are significant gender differences in restoration perceptions. Although there was no statistically significant results for retreat, there is a clear difference in the perspectives between men and women as seen in Tables 10 and 11 (and illustrated in Figure 10). Literature (Bord and O'Connor 1997, Davidson and Freudenburg 1996, O'Connor et al. 1999) support our finding that women have been found to be more sensitive to ecological risks, perceive greater vulnerability, rate risks higher than men, and express more concern because they care about the safety of their communities and families.

Although the communities of south Terrebonne Parish prefer adaptation practices that do not involve retreat, there are recognized constraints at the individual and community level that must be addressed in order for such practices to become effective. First, there needs to be leadership that is capable of telling the residents about their adaptation options (Randal 2009). Those who think that their community lacked leadership showed to have significantly higher likelihoods of rejecting the prospects of successful future wetland restoration. On resident voiced, "We need politicians to tell us the honest truth to hear our options for survival". Second, residents need to overcome the individual constraint of thinking climate change preparation is too expensive. As indicated by our regression results, residents who believe it is too expensive to prepare for climate change have a significantly higher likelihood of thinking preparation is not worth it. It is true that the implementation state plans such as Louisiana's 2012 Coastal Master Plan drafted wetland restoration costs billions of dollars (CPRA). However, the drafting of these plans involve little collaboration with the communities. This causes

residents to feel left out of the process (Burley 2010) and indirectly impact how residents perceive the economic cost of restoration. As it is, conflicts exists between communities and those currently in charge of restoration decision making (e.g., scientists, engineers, government officials). When presented with the statement, "Those involved in restoration efforts should be informed only by scientific experts", the majority of residents disagreed (see Figure 11). Similarly, most residents feel that they should be consulted and actively involved in decisions regarding coastal restoration as shown in Figure 12 and reflected in the following statement made by a resident:

How can you begin to tell us anything at all when you've not come down here? You have to get in it. You have to talk to the people who've been here for 40 to 50 years plus because they can tell you everything. Honestly, the best scientists are the people in the community.

If residents become actively involved in restoration plans, they would be able to have well-informed views about the impacts of climate change and move towards proactive adaptation.

One way to address the issues of community involvement and lack of climate change information is by incorporating participatory action research when developing adaptation strategies. As experienced in the field, PAR in south Terrebonne Parish requires a substantial amount of time for integration and validation into the community of interest. The researcher must also be considerate of the residents' time and schedules so as to not inconvenience them. As state by Burley (2010), the adoption of PAR into adaptation decision making and planning would be "arduous and almost certainly painful". However, the benefits greatly outweigh the challenges. For example, the

relationship between the communities and researchers would improve because of the unaccustomed collaboration between those at the grassroots level and those at the "top". During the course of the present study, residents went from being disinterested about our project to showing genuine excitement about the prospect of getting their voice heard (Feyerabend et al. 2007). The excitement was in turn impacted by the PAR aspect of community ownership. *Vanishing Points*™ was created with the intention of full communal ownership and maintenance. If the same was applied for restoration strategies, residents would be motivated to practice proactive adaptation because of the assumed responsibilities associated with ownership. The use of PAR additionally increases self-worth and self-value resulting from the outward appreciation and respect of community knowledge (Cornwall and Jewkes 1995). The initial reaction of residents to the project involved the referral of "more qualified" individuals. They had to be assured that no formal education or scientific background was necessary for the information sought after. Once it was realized that they would be teaching the researcher about their local knowledge (Mercer et al. 2010, Taylor et al. 2011), any apprehension to participate in the projected was put at ease. If adaptation planning involved a "student-teacher" relationship, residents would start to openly voice their opinions and gain confidence in making influential contributions to climate change adaptation.

Not only did PAR foster the aforementioned benefits, the creation of the mobile application provided a tool for archiving the cultural history and progression of land loss. As previously mentioned, their culture has been passed down orally and by living as their ancestors once did. Concerns arise with the intergenerational transmission of culture to the younger generation. Currently, older residents are witnessing their children leave the

communities because of 1) better employment opportunities and 2) the lack of land available to accommodate both the older and younger generations. If the youth of the communities realized the communal importance and value of preserving their, this exodus would not be at such a large scale. In addition, *Vanishing Points*^{TM} is able to show the younger generation the detrimental impacts of land loss throughout the years. Intuitively, it is difficult for those who are younger than 40 years of age to personally experience and witness the impacts of land loss. However, features such as community scale land loss animations and before and after pictures depicting the geomorphological changes (seen in Figure 9) will be essential in helping the younger generation understand the severity of land loss and climate change impacts. With such an understanding, the youth will be motivated to become proactive in saving their land – a prominent request among older residents. Currently, there are plans of involving the youth in building up the framework of *Vanishing Points*^{TM}. By teaching them the mechanisms of participatory action research, the younger generation will be able to collect cultural data from their own families. This would foster collaboration between the older and younger generations and create an exchange of knowledge within the communities.

Vanishing Points^{TM} will also be an important instrument of exchanging knowledge between the communities of south Louisiana and those at the state and national levels. If the state of Louisiana has true intentions of protecting their coastline, decision makers need to consider both the environmental and social risks. *Vanishing Points*^{TM} showcases the culturally important locations of south Terrebonne Parish and can provide decision makers information necessary to completed cultural risk assessments. Conversely, the application can be used as a tool to give residents climate change related

information from the national and state level. As indicated in our results, community members do not feel sufficiently informed about the impacts of climate change and sea level rise. Additionally, they expressed that a mobile application can be a significant means of informing them with climate change adaptation information.

In the end, the implications of adopting participatory action research into current adaptation strategies and planning requires the willingness of local and state legislatures to accept the associated challenges yet welcome the benefits of community collaboration. Our study established the framework of a PAR project that serves as an example of how local knowledge can influence future adaptation preferences and practices of the community and state alike. Simultaneous research involved the assessment of the impacts of various influences on residents' preference of two adaptation options – retreat and protection. The preliminary nature of our survey provided several insights to the risk perception and place attachment factors. However, additional research should increase the sample size to enable more robust statistics and results. The language and literacy barriers encountered resulted in a low number of survey respondents. Future research can overcome such barriers by using translators, increasing the number of researchers in the field, or exploring alternative modes of effective survey distribution. While the adaptation options of retreat and protection were explored, an assessment of residents' attitude towards accommodation would enable a deeper analysis of future adaptation preferences in south Terrebonne Parish. A completed analysis of climate change adaptation would include the assessment of the adaptive capacity of these communities as well (Grothmann and Patt 2003). In the meanwhile, further research is being conducted

using the extensive qualitative data collected during our study (e.g., during survey administration and content gathering for *Vanishing Points*^{TM})

To close, the following is a foreword from Jonathan Foret, the Executive Director of the South Louisiana Wetlands Discovery Center (SLWDC), emulating the important role of acknowledging culture in future climate change adaptation.

There are many cultures along the bayous of Terrebonne Parish that contribute to the unique flavor of this area. The indigenous population of Native Americans, the Cajun settlers from Nova Scotia, African Americans, Vietnamese fisherman, and most recently, Spanish speaking migrant workers all come together in this bayou region making it a place like no other. Although each of these cultures are separated by specific traditions, foods and even languages, the one thing that unites them all is a connection to the land. Whether harvesting seafood from the waters or extracting oil from under the earth, these people have used the land to support their families for generations. Some people have supported the conservation of this land while others have supported its exploitation, but each is dependent on it. They are dependent on it for food, for a livelihood and for storm protection. But, this land is vanishing faster than it can be replaced. With the disappearance of this land, these bayou cultures become more and more threatened. The diaspora can already be seen as schools begin to close and populations in vulnerable communities dwindle. Despite the fact that these communities are the "canary in the coal mine" for climate change, the people of Terrebonne Parish really do exhibit a "joie de vivre" or joy for life. This is displayed through festivals throughout the year, Mardi Gras celebrations, religious gatherings, and any other thing you may think to celebrate including Hurricane Parties. However, their 'joie de vivre" should not be mistaken for

naiveté. These people have intimate knowledge of the situation facing them from more frequent and stronger storms to less land around to protect them, but they are dedicated to celebrating their culture with dignity and with the hope that they will be able to continue to do so for generations to come.

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Table 1. Comparison of participatory and conventional research (adopted from Cornwall and Jewkes 1995)

	Local People	Shared	Researcher
Who is the research for?	◊		*
Whose knowledge is valued?	◊		*
Who identifies the problem?	◊		*
Who collects the data?	◊		*
Who takes action after presentation of findings?	◊		*
Who owns the results?		◊	*

Legend: ◊ =Participatory research, * = conventional research

Table 2. Benefits and limitations of integrating TEK (Cornwall and Jewkes 1995, Mercer et a. 2008)

Benefits	Limitations
• Reverses tendency of focusing on a community's weakness	• Belief that scientific knowledge is "superior"
• Recognizes the local people's ability to assess risk and communicate it with community and between generations	• Local knowledge and practices are complex and diverse
• Allows for an understanding of local needs that influence the response of the people to risk	• Disaster preparedness has been seen only a national defense and/or security problem
• Fosters community participation at all research stages	• Impact of multiple hazard stresses make TEK inaccessible over time due to its rapid and constant change

Table 3. Variables, corresponding survey questions, and descriptive statistics.

Variable	Survey Question
Decision-making Variables	
Abandon	How likely is it that your community will have to be abandoned by 2050 due to land loss? (1) Very unlikely, (2) Unlikely, (3) Neutral, (4) Likely, (5) Highly likely
Restore	Do you think the coastal wetlands of south Terrebonne parish can be successfully restored? (1) Yes, (0) No
Explanatory Variables	
Threat	Climate change and sea level rise are threatening my quality of life. (1) Yes = Strongly agree, (0) No = Tend to agree to Strongly disagree
Landloss	My community is currently feeling the effects of land loss. (1) Yes, (2) No
Connection	I feel as if I'm losing my connection with the land because of the impacts of climate change and sea level rise. (1) Yes = Strongly agree, (0) No = Tend to agree to Strongly disagree
Vegetation	Have you seen a decrease of vegetation due to land loss? (1) Yes, (0) No
Notworth	The following is a constraint I feel is stopping me from taking more action to prepare for climate change and sea level rise: I do not think it's worth it. (1) Yes, (0) No
Tooexpensive	The following is a constraint I feel is stopping me from taking more action to prepare for climate change and sea level rise: It is too expensive. (1) Yes, (0) No
Weather	Has there been a higher frequency and intensity of extreme weather events due to climate change and sea level rise? (1) Yes, (0) No
Vulnerable	How vulnerable do you think your community is to extreme weather events (hurricanes and floods) in the next 10 years? (1) Not at all, (2) Slightly, (3) Somewhat, (4) Moderately, (5) A great deal
Damage	Did any of the experienced storms cause damage to your property? (1) Yes, (0) No
Informed	Do you think you are sufficiently informed about the current and future impacts of climate change and sea level rise? (1) Yes, (0) No
Evacuation	Number of evacuations within past 10 years
Noleadership	Do you think your community faces a lack of leadership and direction that constraints your community from taking action to prepare for climate change and sea level rise? (1) Yes, (0) No
Mobileapp	How useful do you think a mobile application would be for providing climate change adaptation information? (1) Not at all useful – (5) Very useful
Gender	Gender (1) Male, (2) Female
Income	Annual income (1) <$15,000, (2) $15,000-$24,999, (3) $25,000-$34,999, (4) $35,000-$49,999, (5) $50,000-$74,999, (6) $75,000-$99,999, (7) > $100,000
Residency	How many years have you lived in south Terrebonne Parish? Continuous numerical response
Household	How many individuals live in your household? Continuous numerical response
Agriculture	Is your current field of occupation in agriculture (fisherman, farming, etc.)? (1) Yes, (0) No
Science	Is your current field of occupation in science? (1) Yes, (0) No
Nonprofit	Is your current field of occupation in non-profit, service, or community work? (1) Yes, (0) No
Elderly	There is one or more individual(s) over the age of 65 living in my household.
Children	There is one or more individual(s) under the age of 18 living in my household. (1) Yes, (0) No

Table 4. Ologit estimated probability and marginal effects for the likelihood of community abandonment by 2050 (*Abandon*).

	Independent Variables	Model 1†		Model 2†	
		Estimation	Marginal Effect	Estimation	Marginal Effect
	Threat	1.96(0.60)***	-0.10(0.04)**	1.64(0.57)***	-0.06(0.03)**
	Vegetation	1.02(0.58)*	-0.50(0.03)		
	Weather	-1.27(0.63)**	0.06(0.03)*		
	Landloss			2.76(0.63)***	-0.10(0.03)***
	Notworth			1.78(0.68)***	0.07(0.04)**
	Vulnerable			1.53(0.43)***	-0.07(0.04)***
Controls	*Evacuation*	0.42(1.14)***	-0.02(0.01)**		
	Income	-0.03(0.10)	0.00(0.00)	-0.08(0.11)	0.00(0.00)
	Gender	0.30(0.50)	-0.01(0.03)	0.42(0.48)	-0.02(0.02)
	Household			0.11(0.13)	0.00(0.00)
	Damage			0.90(0.56)	-0.03(0.03)
	N	84	84	80	80
	Pseudo R^2	0.16	0.16	0.20	0.20
	Wald(χ^2)	25.72	25.72	39.54	39.54

***, **, * Significance at 1%, 5%, and 10% levels, respectively

† Values within parenthesis are robust standard errors

Table 5. Bivariate oprobit estimated probability for the likelihood of community abandonment by 2050 (*Abandon*) and worth of climate change preparation (*Notworth*).

	Independent Variables	Model 5†		Model 6†	
		Abandon	**Notworth**	**Abandon**	**Notworth**
	Notworth	1.28(0.78)*		1.33(0.68)**	
	Threat	0.78(0.32)***		0.71(0.33)**	
	Landloss	1.25(0.36)***		1.20(0.35)***	
	Vulnerable	0.79(0.23)***		0.78(0.23)***	
	Tooexpensive		1.18(0.44)***		2.01(0.61)***
	Elderly		-8.66(0.56)***		-8.95(0.86)***
	Mobileapp				0.47(0.26)*
	Agriculture				2.02(0.86)***
Controls	*Gender*	0.36(0.31)	-0.19(0.40)	0.35(0.30)	-0.43(0.51)
	Household	0.05(0.08)		0.05(0.09)	
	Income	-0.04(0.07)	-0.07(0.12)	-0.05(0.08)	-0.11(0.17)
	Damage	0.51(0.31)*		0.48(0.33)	
	Residency		0.02(0.01)		0.01(0.02)
	N	72	72	69	69
	Log psuedolikelihood	-102.71	-102.71	-90.78	-90.78

***, **, * Significance at 1%, 5%, and 10% levels, respectively

† Values within parenthesis are robust standard errors

Table 6. Logit estimated probability and marginal effects for successful restoration of south Terrebonne's coastal wetlands (*Restore*).

	Independent Variables	Model 3†		Model 4†	
		Estimation	Marginal Effect	Estimation	Marginal Effect
	Notworth	-2.91(0.95)***	-0.35(0.09)***	-2.53(0.89)***	-0.29(0.09)***
	Threat	-1.86(0.76)***	-0.22(0.08)***	-1.81(0.85)**	-0.21(0.09)**
	Noleadership			-0.88(0.89)	-0.10(0.10)
Controls	*Household*	0.01(0.20)	0.00(0.02)	0.03(0.21)	0.00(0.02)
Controls	*Gender*	-1.69(0.90)*	-0.20(0.10)**	-1.27(0.80)	-0.14(0.09)
Controls	*Income*	-0.25(0.19)	-0.03(0.02)	-0.32(0.21)	-0.04(0.02)
Controls	*Evacuation*	-0.05(0.18)	-0.01(0.02)	-0.12(0.20)	-0.01(0.02)
Controls	*Science*			-1.15(1.40)	-0.13(0.15)
Controls	*Nonprofit*			0.23(0.96)	0.03(0.11)
	Constant	6.90(2.61)***		7.14(2.41)***	
	N	79	79	78	78
	Pseudo R^2	0.22	0.22	0.24	0.24
	Wald(χ^2)	16.41	16.41	19.61	19.61

***, **, * Significance at 1%, 5%, and 10% levels, respectively

† Values within parenthesis are robust standard errors

Table 7. Bivariate probit estimated probability for successful restoration of south Terrebonne's coastal wetlands (*Restore*) and threat to quality of life (*Threat*).

	Independent Variables	Model 7†		Model 8†	
		Restore	**Threat**	**Restore**	**Threat**
	Threat	-2.10(0.38)***		-1.47(0.57)***	
	Notworth	-0.56(0.44)*		-1.67(0.48)***	
	Noleadership	-0.41(0.45)		0.01(0.67)	1.05(0.45)***
	Informed		-0.44(0.26)*		-1.11(0.50)**
	Agriculture		1.31(0.48)***		
	Connection				2.78(0.56)***
Controls	*Residency*		0.00(0.01)		0.00(0.01)
	Children				-0.28(0.49)
	Middle				0.14(0.46)
	Household	0.13(0.18)		0.01(0.14)	
	Gender	-0.51(0.41)	-0.05(0.31)	-1.58(0.55)***	-0.62(0.47)
	Income	-0.28(0.11)***		-0.24(0.11)**	-0.15(0.12)
	Evacuation	-0.04(0.11)		-0.07(0.14)	
	Science	-6.62(0.41)***		-6.54(0.58)***	
	Nonprofit	-0.06(0.26)		0.75(0.48)	
	Constant	3.67(0.79)***		5.30(1.34)***	-2.20(1.07)**
	N	68	68	66	66
	Log psuedolikelihood	-64.26	-64.26	0.24	0.24

***, **, * Significance at 1%, 5%, and 10% levels, respectively

† Values within parenthesis are robust standard errors

Table 8. Cross tabulation of variables *Abandon* and *Landloss* including frequency and percentages

		Effects of land loss are currently being seen		
		No	**Yes**	**Row Totals**
How likely is it that your community will have to be abandoned by 2050 due to land loss?	**Very unlikely**	3	5	8
	Row Percent	37.50%	62.50%	6.50%
	Unlikely	1	5	6
	Row Percent	16.67%	83.33%	4.88%
	Neutral	3	28	31
	Row Percent	9.68%	90.32%	25.20%
	Likely	0	23	23
	Row Percent	0.00%	100.00%	18.70%
	Highly likely	2	53	55
	Row Percent	3.64%	96.36%	44.72%
	Column Totals	9	114	123
	Column Percent	7.32%	92.68%	100.00%

Table 9. Cross tabulation of variables *Restore* and *Notworth* including frequency and percentages

		It is not worth it to prepare for climate change and sea level rise		
Do you think the coastal wetlands of south Terrebonne can be successfully restored?		**No**	**Yes**	**Row Totals**
	No	21	7	28
	Row Percent	75.00%	25.00%	23.33%
	Yes	84	8	92
	Row Percent	94.44%	5.56%	76.67%
	Column Totals	105	15	120
	Column Percent	87.50%	12.50%	100.00%

Table 10. Cross tabulation of variables *Abandon* and *Gender* including frequency and percentages

		Gender		
		Male	**Female**	**Row Totals**
How likely is it that your community will have to be abandoned by 2050 due to land loss?	**Very unlikely**	6	2	8
	Row Percent	75.00%	25.00%	6.78%
	Unlikely	2	4	6
	Row Percent	33.33%	66.67%	5.08%
	Neutral	11	19	30
	Row Percent	36.67%	63.33%	25.42%
	Likely	8	14	22
	Row Percent	36.36%	63.64%	18.64%
	Highly likely	18	34	52
	Row Percent	34.62%	65.38%	44.07%
	Column Totals	45	73	118
	Column Percent	38.14%	61.86%	100.00%

Table 11. Cross tabulation of variables *Restore* and *Gender* including frequency and percentages

		Gender		
Do you think the coastal wetlands of south Terrebonne can be successfully restored?		**Male**	**Female**	**Row Totals**
	No	9	16	25
	Row Percent	36.00%	64.00%	21.74%
	Yes	35	55	90
	Row Percent	38.89%	61.11%	78.26%
	Column Totals	44	71	115
	Column Percent	38.14%	61.74%	100.00%

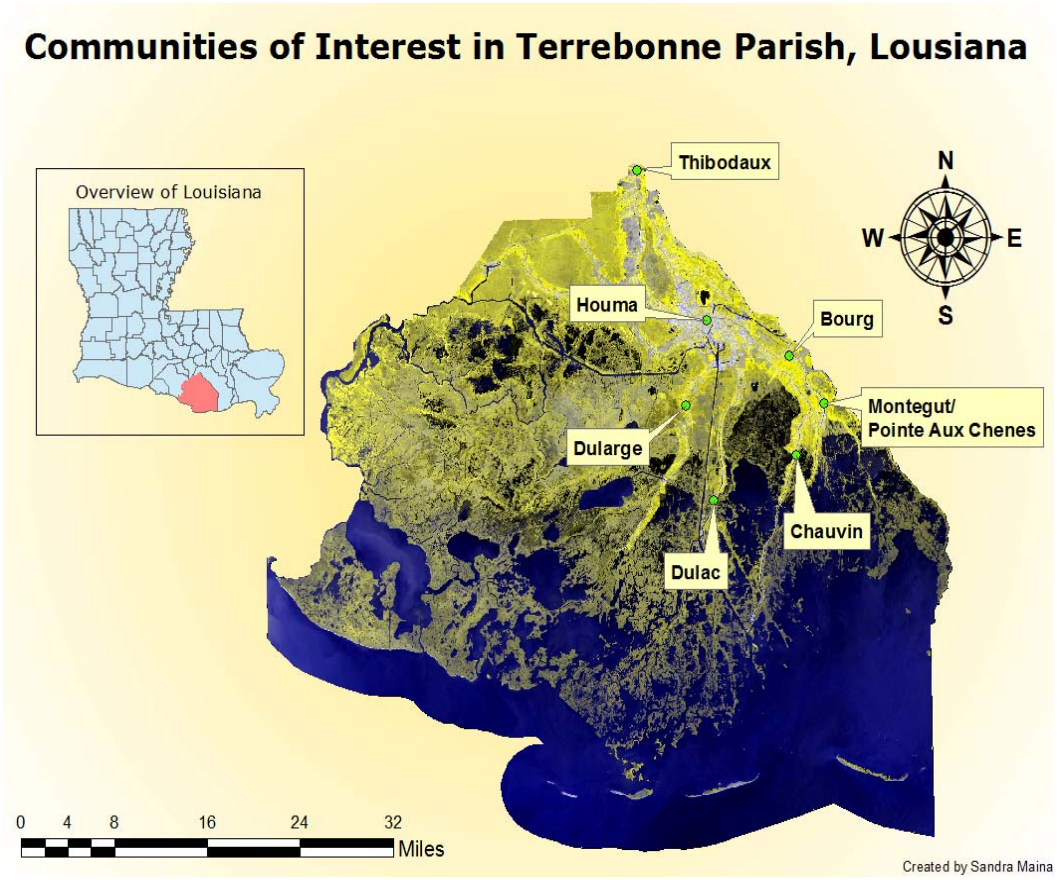


Figure 1. Communities of interest in Terrebonne Parish, Louisiana.

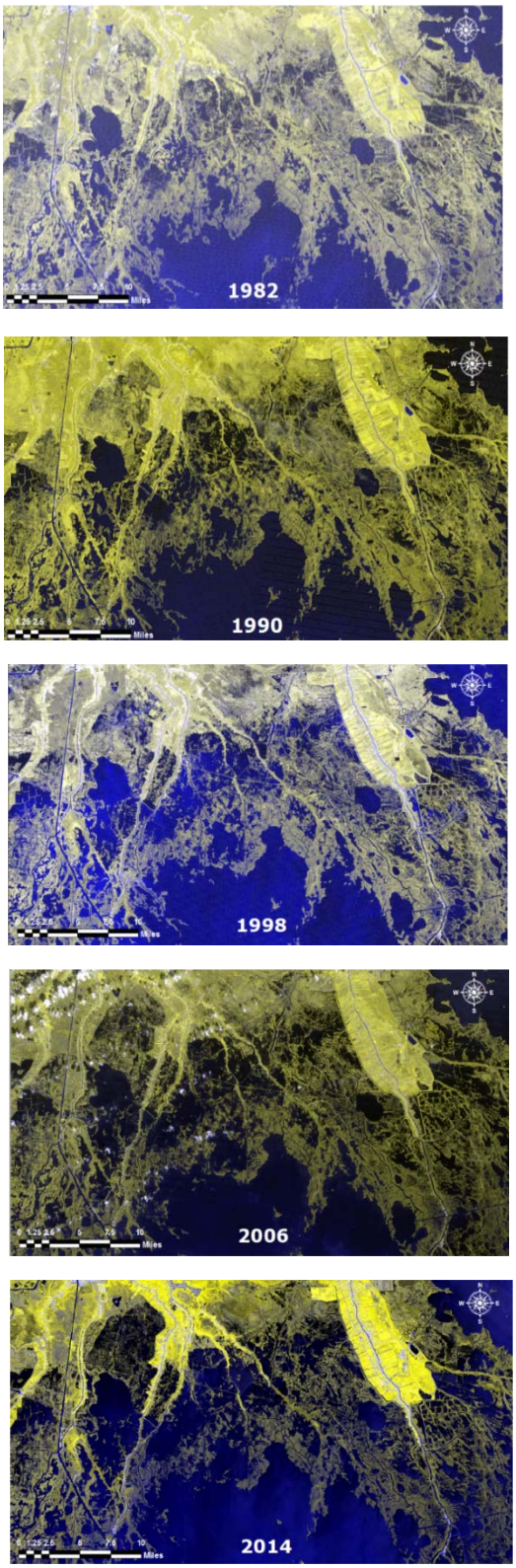


Figure 2. Time series of Terrebonne Parish land loss (Data Source: U.S. Geological Survey)

Figure 3. Ghost forests in Dularge, LA as a result of salt water intrusion impacts.

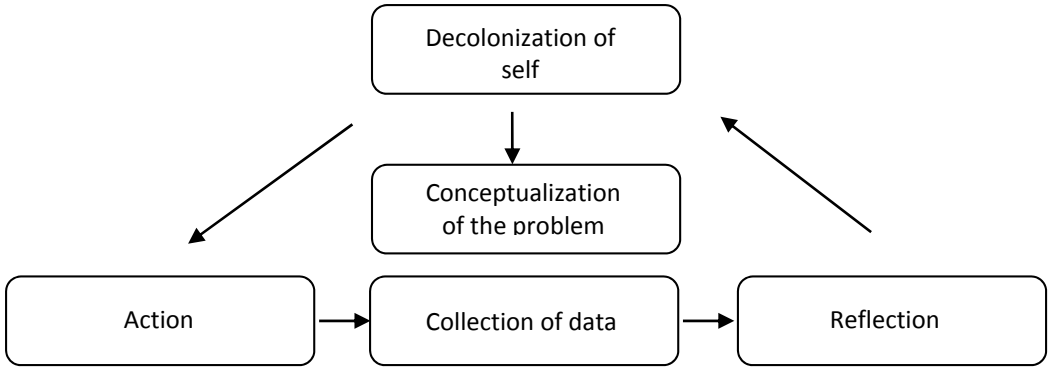


Figure. 4 Cyclical framework of participation action research.

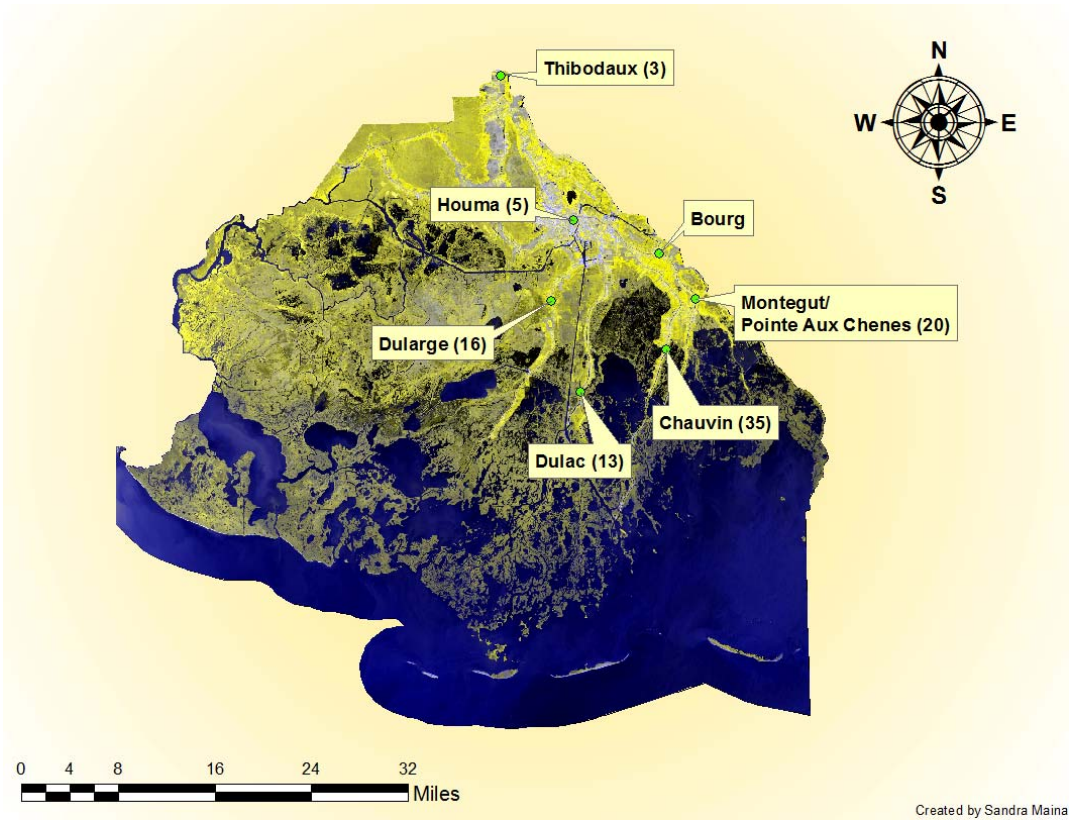


Figure 5. Number of completed surveys throughout the communities of south Terrebonne Parish.

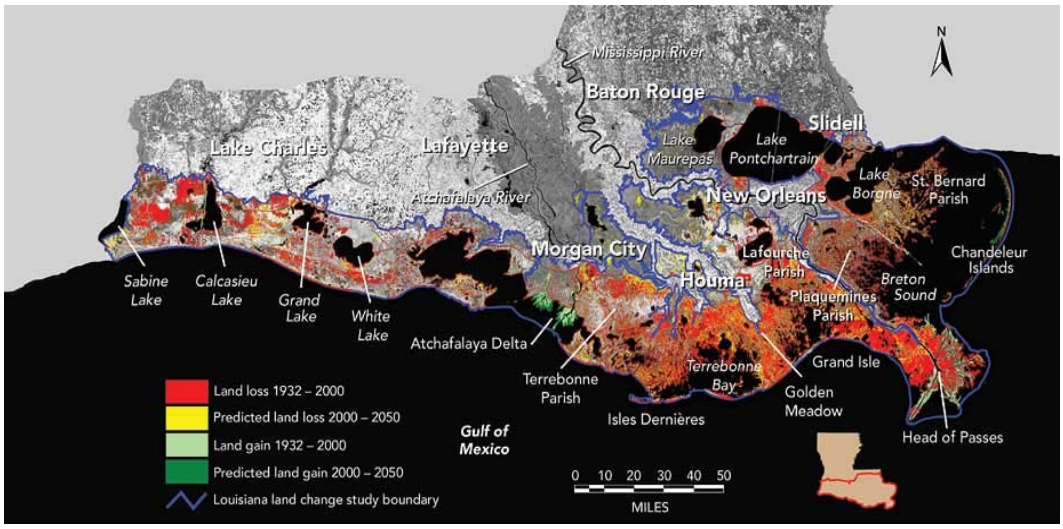


Figure 6. U.S. Geological Survey National Wetlands Center Land loss and projection map.

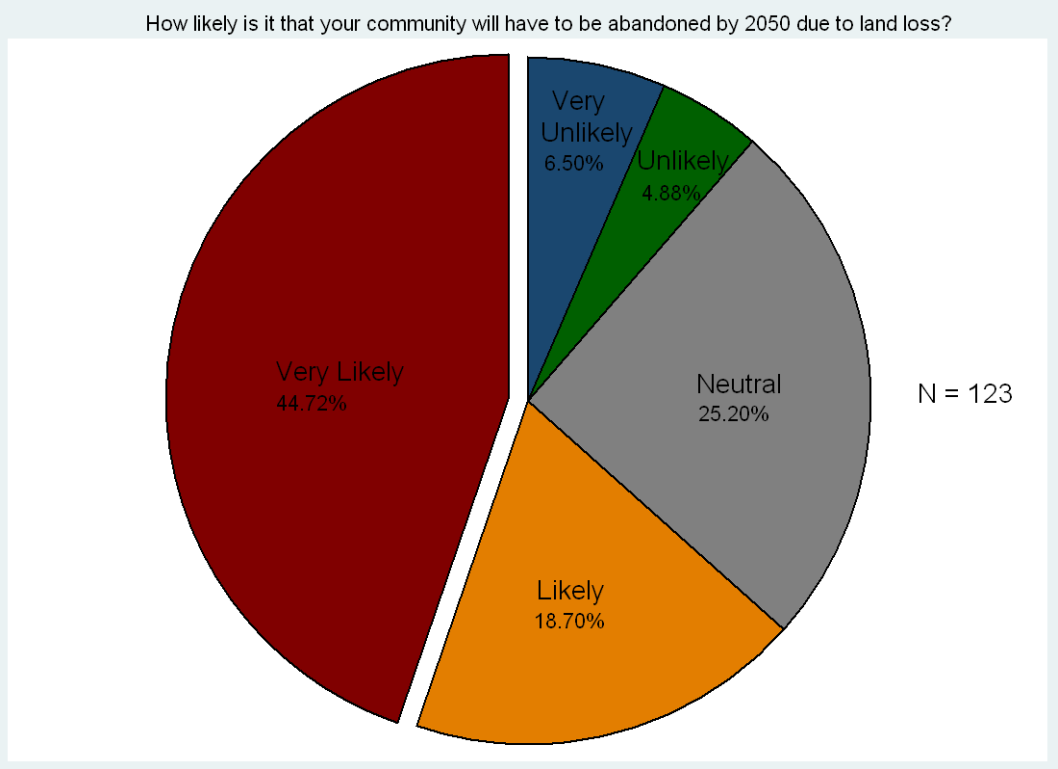


Figure 7. Pie chart of participant responses to the folloing survey question: How likely is it that your community will have to be abandoned by 2010 due to land loss.

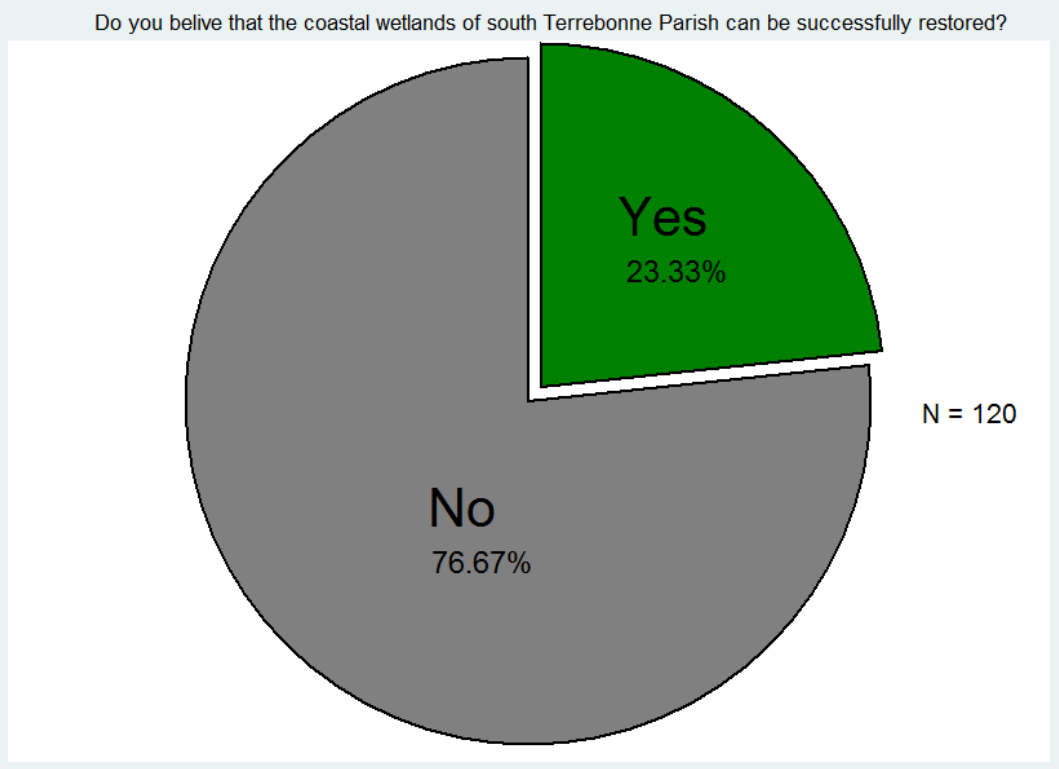


Figure 8. Pie chart of participant responses to the following binary survey question: Do you think the coastal wetlands of south Terrebonne Parish can be successfully restored.

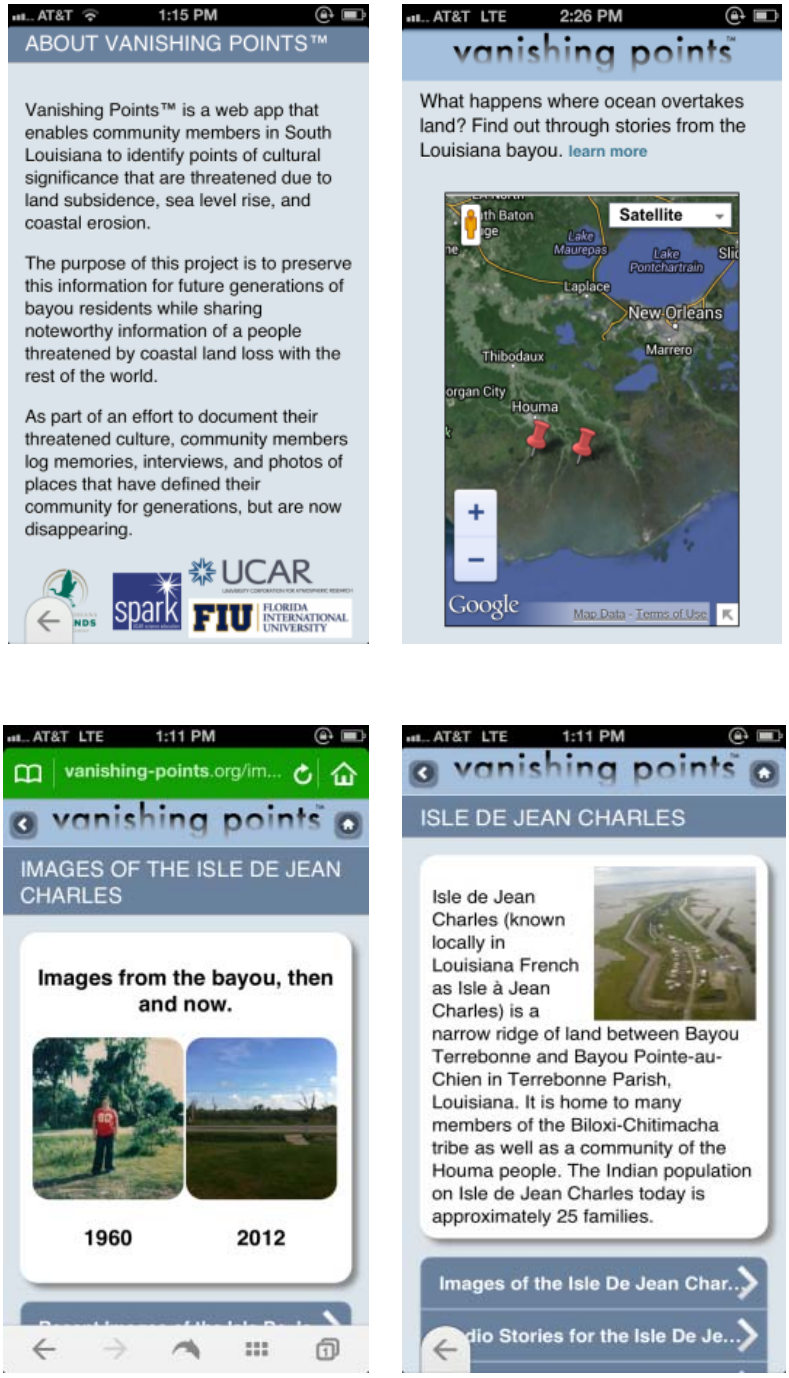
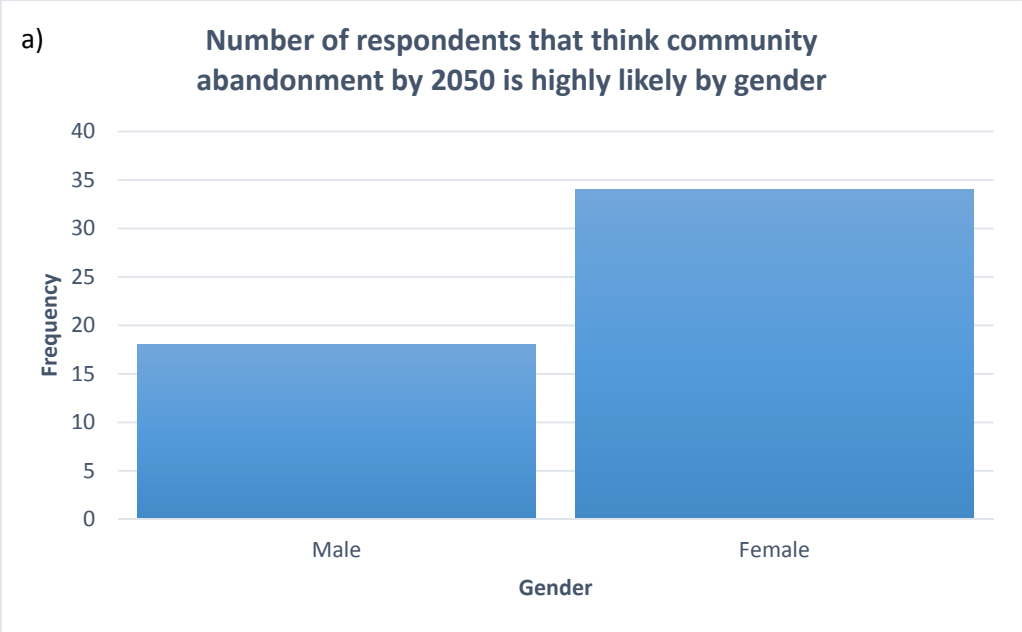


Figure 9. Vanishing Points™ screenshots.



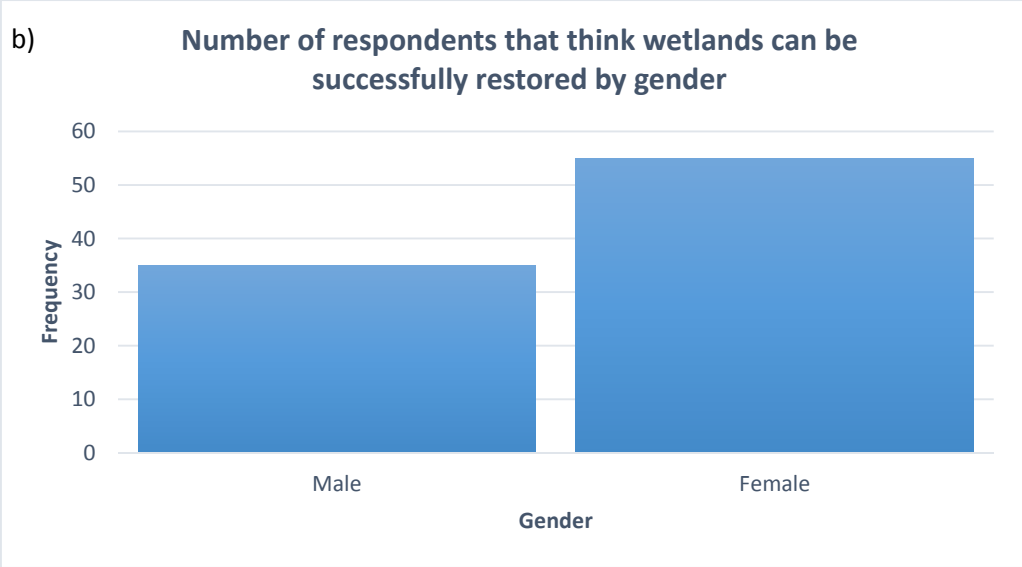


Figure 10. Adaptation preferences by gender

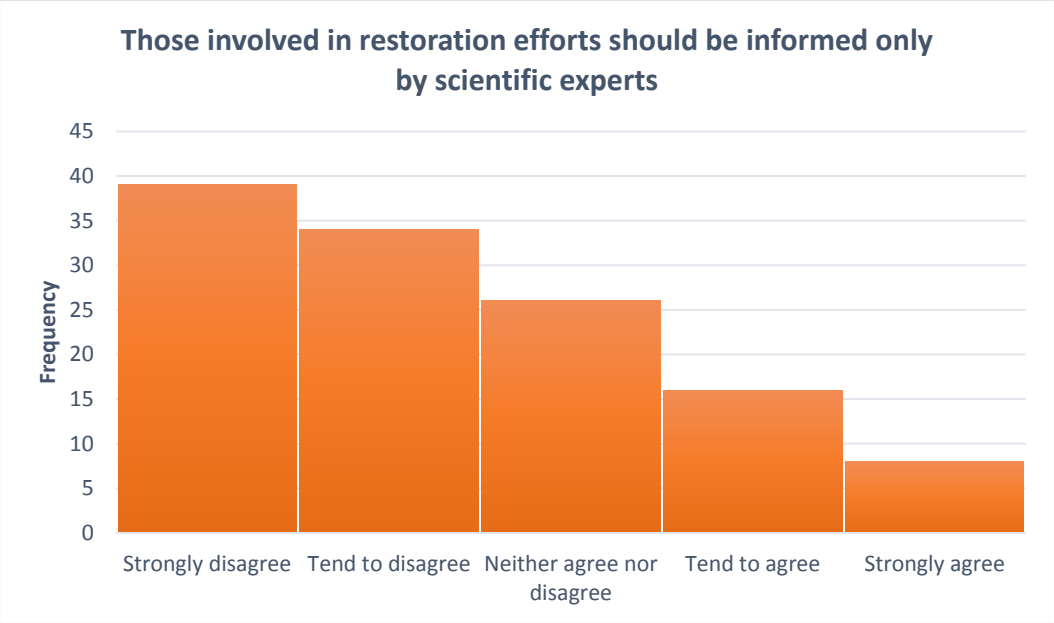


Figure 11. Histogram for the survey statement: Those involved in restoration efforts should be informed only by scientific experts.

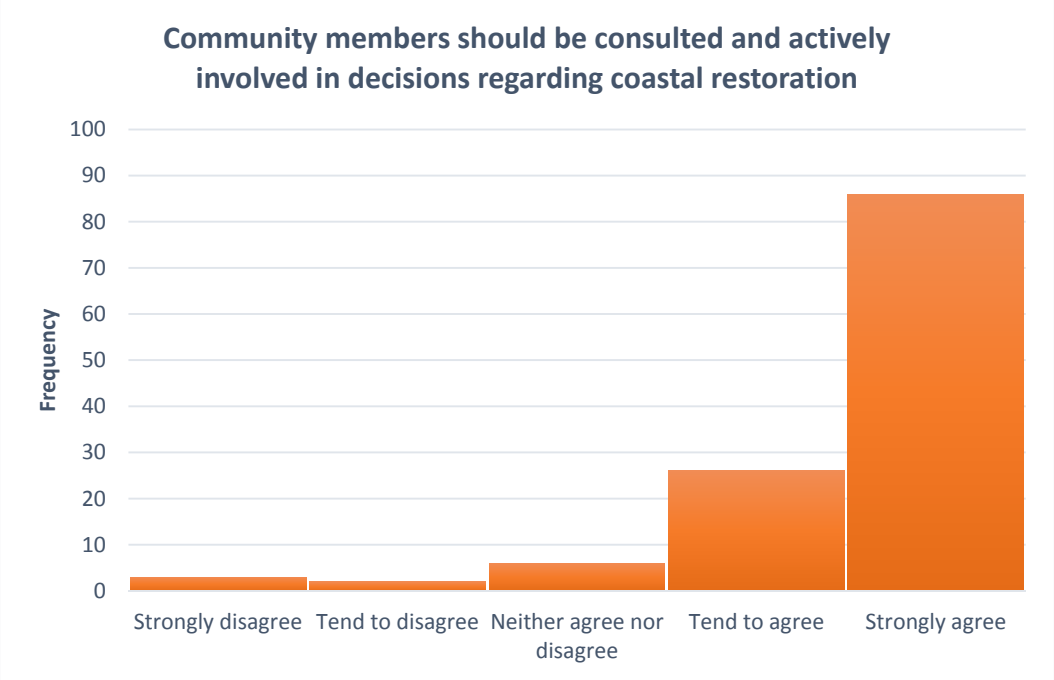


Figure 12. Histogram for the survey statement: Community members should

APPENDIX A

SOUTH TERREBONNE PARISH INTERVIEW SURVEY

South Terrebonne Parish currently face challenges related to the impacts of land loss, climate change, and sea level rise. This survey seeks to understand how the residents of several vulnerable communities feel about these impacts. Your participation is greatly appreciated.

PART 1: Your community and land loss challenges. In this section we are interested on how connected you feel to your surrounding environment and the impacts of land loss.

[Q1] How do you feel about your current natural environment? Please circle to what you extent you agree with each statement in the scale from 1 (strongly disagree) to 5 (strongly agree).

	1	2	3	4	5
	Strongly disagree	Tend to disagree	Neither agree nor disagree	Tend to agree	Strongly agree
a) I feel that I share a bond with things in the natural environment around me.	1	2	3	4	5
b) I feel that no harm should come to anything in my natural environment around me.	1	2	3	4	5
c) I respect the life and intelligence of all living things.	1	2	3	4	5

[Q2] About how often are you engaged with the surrounding natural environment for the following activities? Please circle your answer on the scale from 1 (once a year) to 5 (daily).

	1	2	3	4	5
	Once a year	Once a month	2-3 times a month	Once a week	Daily
a) Employment	1	2	3	4	5
b) Volunteer services	1	2	3	4	5
c) Recreation	1	2	3	4	5
d) Leisure/relaxing	1	2	3	4	5

[Q3] Have you seen any land loss related physical changes in your community within the past 10 years? Please select **ALL** the changes you have noticed.

A	Increase of lakes and bodies of open water
B	Widening of bayous and canals
C	Decrease of vegetation
D	Increase of levees and flood walls
E	Slow community development
F	Other, please specify:_____

[Q4] When do you think your community will start feeling the effects of land loss? Please circle the letter corresponding to your answer.

A	We are already feeling the effects
B	In the next 10 years
C	In the next 25 years
D	In the next 50 years
E	In the next 100 years
F	Beyond the next 100 years
G	Never

[Q5] In your opinion, how likely is it your community will have to be abandoned by 2050 due to land loss? Please circle your answer on the scale from 1 (very unlikely) to 5 (highly likely).

Very unlikely				Highly likely
1	2	3	4	5

[Q6] How concerned are you about the consequences of land loss on the following items? Please circle your answer on the scale from 1 (not concerned at all) to 5 (highly concerned).

	Not at all concerned				Highly concerned
a) Wildlife (land and marine) and habitats	1	2	3	4	5
b) Future generations	1	2	3	4	5
c) Living conditions in my community	1	2	3	4	5
d) Employment	1	2	3	4	5
e) Other, please specify:_____	1	2	3	4	5

Part 2: Saving the land. In this section, we are interested in your thoughts about coastal wetland restoration.

[Q7] Do you believe that the coastal wetlands of south Terrebonne parish can be successfully restored? Please circle.

Yes No

[Q8] Which do you think is necessary to combat land loss in south Terrebonne Parish? Please circle the choice that best reflects your opinion.

	It is necessary	It is not necessary	Don't know
a) River diversions	Y	N	DK
b) Sediment pipeline diversions	Y	N	DK
c) Restoration of the barrier islands	Y	N	DK
d) Other, please specify:_____	Y	N	DK

[Q9] To what extent do you agree or disagree with each of the following statements about land restoration?

	1 Strongly disagree	2 Tend to disagree	3 Neither agree nor disagree	4 Tend to agree	5 Strongly agree
a) Those involved in restoration efforts should be informed only by scientific experts.	1	2	3	4	5
b) Community members should be consulted and actively involved in decisions regarding coastal restoration.	1	2	3	4	5
c) Contributions from community members are accepted by current restoration decision makers.	1	2	3	4	5
d) Contributions from community members are accepted by scientific experts.	1	2	3	4	5

Part 3: Climate change and sea level rise in your community. In this section, we are interested in your opinions about the impacts of climate change and sea level rise on your community.

[Q10] Do you think that climate change has made impacts to your community? Please circle. *(Skip to question Q16 if you select no)*

Yes No

[Q11] How concerned are you with the impacts of climate change and sea level rise? Please circle your answer on the scale from 1 (not at all concerned) to 5 (highly concerned).

Not at all concerned				Highly concerned
1	2	3	4	5

[Q12] Which of the following changes are related to the impacts of climate change and sea level rise? Please circle **ALL** that apply.

A Decrease of water quality
B Salt water intrusion damage to freshwater ecosystem
D Land loss
E Higher frequency and intensity of extreme weather events
F Decrease of marine life
H Widening canals and water ways
I Slow community growth
J Other, please specify:_____

[Q13] To what extent do you agree or disagree with each of the following statements about your feelings on climate change and sea level rise?

	1	2	3	4	5
	Strongly disagree	Tend to disagree	Neither agree nor disagree	Tend to agree	Strongly agree
a) Climate change and sea level rise are threatening my quality of life.	1	2	3	4	5
b) I worry about the impacts of climate change and sea level rise on our future generations.	1	2	3	4	5
c) I have thought about relocating my family because of the impacts of climate change and sea level rise.	1	2	3	4	5
d) I feel as if I'm losing my connection with the land because of the impacts of climate change and sea level rise.	1	2	3	4	5

[Q14] What constraints do you feel stop <u>you</u> from taking more action to prepare for climate change and sea level rise? Please circle **<u>ALL</u>** that apply.

A I don't think it exists
B I don't think it's worth it.
C I am not aware of anything else I can do.
D It is not necessary.
E It's too expensive.
F I'm not interested or motivated.
G It's too time consuming
H Other, please specify:_____

[Q15] What constraints do you think <u>your community</u> faces in taking action to prepare for climate change and sea level rise? Please circle **<u>ALL</u>** that apply.

A Lack of public awareness.
B Lack of interest and motivation.
C Uncertainty in scientific information.
D Lack of assistance from state and federal agencies.
E Lack of financial support.
F Lack of leadership and direction.
G Other, specify:_____

[Q16] Do you think you are sufficiently informed about the current and future impacts of climate change and sea level rise? Please circle.

Yes No

[Q17] Where do you receive your information on the impacts of climate change and extreme weather events (i.e. hurricanes)? Please circle **<u>ALL</u>** that apply.

A Television and radio
B Internet
C Community members
D State/government officials
E Non-profit representatives
F Other, specify:_____

[Q18] How useful do you think each of the following would be for providing climate change adaptation information to community members? Please circle your answer on the scale from 1 (not at all useful) to 5 (very useful).

	Not at all useful				Very useful
a) Regular community workshops and seminars	1	2	3	4	5
b) Website	1	2	3	4	5
c) Mobile application	1	2	3	4	5
d) Online forums and chat rooms	1	2	3	4	5
e) Regular distribution of pamphlets	1	2	3	4	5
f) Social media (Facebook, Twitter, etc)	1	2	3	4	5

Part 4: Past extreme weather event experiences. In this section, we would like to know a bit about your previous experiences with extreme weather events such as hurricanes and floods.

[Q19] How vulnerable do you think your community is extreme weather events (hurricanes and floods) in the next 10 years? Please circle your answer on the scale from 1 (not at all) to 5 (a great deal).

Not at all				A great deal
1	2	3	4	5

[Q20] Which of the following extreme weather events have you experienced in the past 10 years? Also, did you evacuate for these storms? Please circle **ALL** that apply and indicate if you evacuated for each circled storm.

		Did you evacuate?	
A	Tropical Storm Matthew (2004)	Yes	No
B	Hurricane Cindy (2005)	Yes	No
C	Hurricane Katrina (2005)	Yes	No
D	Hurricane Rita (2005)	Yes	No
E	Hurricane Humberto (2007)	Yes	No
F	Hurricane Ike (2008)	Yes	No
G	Tropical Storm Bonnie (2010)	Yes	No
H	Tropical Storm Lee (2011)	Yes	No
I	Hurricane Isaac (2012)	Yes	No

[Q21] If you circled no for any of the storms above, which of the following provides a reason for not evacuating? Please circle **ALL** that apply. *(Skip to question Q22 if you evacuated for all storms)*

A There were financial constraints.
B We had nowhere to evacuate to.
C One or more of my family members has mobility constraints.
D There were vehicle constraints.
E I have enough experience with this or these event(s).
F Other, please specify: _____

[Q22] What source(s) did you depend on for information about the storm(s)? Please circle **ALL** that apply and indicate with a check mark if it was before and/or during the storm(s).

		Before	After
A	Radio		
B	Television		
C	Internet		
D	Social media (Facebook, Twitter, etc)		
E	Community members		
F	State/government officials		
G	Non-profit representatives		
H	Other, please specify:_____		

[Q23] Did any of the selected storms cause damage to your property? Please circle.
(Skip to question Q25 if Yes No *you select no)*

[Q24] What type of resources did you use to repair damages to your property caused by any of the storms listed above? Please circle **ALL** that apply.

A Personal resources
B Community resources
C State/government resources
D Non-profit resources
E International resources
F Other, please specify:_____

[Q25] Have you done any of the following activities? Please circle.

	Yes	No, but I should	No, it's not necessary
a) Raised your house within the past 10 years.	Y	NS	NN
b) Participate in wetland restoring volunteer activities	Y	NS	NN
c) Saved money in case of an emergency hurricane evacuation.	Y	NS	NN
d) Created a family hurricane evacuation plan.	Y	NS	NN
e) Made definite plans to relocate within the next 10 years.	Y	NS	NN
f) Other, please specify:_____			

Part 5: About you. Finally, we would like to ask you some basic demographic information. This information is for analytic purposes only, not for attribution.

[Q26] Please select your gender: Female Male

[Q27] How old are you? Please select your age group.

A 18-24
B 25-34
C 35-44
D 45-54
E 55-64
F Over 65

[Q28] How many years have you lived in south Terrebonne Parish? _____

[Q29] What is your current field of occupation? Please circle the letter(s) that best corresponds to your answer.

A Agriculture (fisherman, farmers, etc)
B Administration
C Construction
D Education and teaching
E Finance
F Healthcare and medical
G Non-profit, service, and community work
H Manufacturer (oil rig operator, mechanic, technician, etc)
I Sales and marketing
J Science and engineering
K Student
L Unemployed
M Retired

[Q30] What is your annual income? Please select.

A Under $15,000
B $15,000 - $24,999
C $25,000 - $34,999
D $35,000 - $49,999
E $50,000 - $74,999
F $75,000 - $99,999
G $100,000 and up

[Q31] How affordable is flood insurance for your household currently and in the future?

	Affordable	Affordable yet challenging	Not possible to afford
a) Currently	A	AC	NP
b) 5 years from now	A	AC	NP

[Q32] How many individuals live in your household?
Please write the number (i.e. 3, 4, 5). _____

[Q33] Which of the following describes one or more of those living in your household? Please circle **ALL** that apply.

A Under 18 years old
B Over 65 years old
C Disabled
D Pet
E None of the above

[Q34] Which of the following family members lives in your community? Please circle **ALL** that apply.

A Spouse
B Daughter/son
C Niece/nephew
D Aunt/uncle
E Cousin
F Grandmother/grandfather

APPENDIX B

EMAIL RECRUITMENT

Hello,

My name is Sandra Maina, a graduate student from the Department of Earth and Environment at Florida International University. As a part of my studies, I spent last summer creating the foundations of a mobile application called Vanishing Points™. The purpose of the application is to showcase locations that are culturally important throughout the communities in south Terrebonne Parish. Last year, these were some of the main activities I did:

- Asking community members which locations are culturally significant
- Collecting historical pictures that show how much the land has truly changed over the years
- Recording individuals who were willing to share a short story of why that particular location is important
- Creating land loss animations to show how the area around each location has changed

For me, this application is a way for the voices of the communities to be heard. I ultimately would like to see people realize that addressing the problem of land loss is not solely a matter of understanding the geographic processes occurring. It also requires an understanding of the culture and livelihood at risk.

Now as a collaborated effort between the South Louisiana Wetlands Discovery Center, the National Center for Atmospheric Research, and Florida International University, my goal for the summer is to determine how Vanishing Points™ can truly benefit your community as well as all others in south Terrebonne Parish.

In order to do this, I have created a survey that asks basic questions to help me understand even more people's feelings on the impacts of land loss, climate change, and sea level rise. If you do choose to take the survey, it will take about 20 minutes to complete and your responses will remain completely anonymous.

I would like to graciously invite you to this great opportunity that will allow your voice to be heard and influence future climate change adaptation plans. Please follow the link provided below to take the survey. You must be over the age of 18 and live in south Terrebonne Parish. It would also be of great help to share this link to anyone else that is qualified.

https://fiu.qualtrics.com/SE/?SID=SV_9BOiH3ImOSjE1ql

I am truly grateful for all the support I have already received and will extend that to you as well if you so do choose to participate. Once the duration of the study is over, Vanishing Points™, including any of your contributions, will be made accessible to the public.

If you have any questions or comments, please feel free to contact me by email (smain007@fiu.edu) or by phone (301-814-3054).