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Community Risk and Resilience to Climate Hazards and Extreme Events in the Turtle Region of Trinidad

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Community Risk and Resilience to Climate Hazards and Extreme Events in the Turtle Region of Trinidad

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Urban Planning

by

Tisha Terrianne Joseph Holmes

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ABSTRACT OF THE DISSERTATION

Community Risk and Resilience

to Climate Hazards and Extreme Events

in the Turtle Region of Trinidad

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Tisha Terrianne Joseph Holmes

Doctor of Philosophy in Urban Planning

University of California, Los Angeles, 2015

Professor Susanna B. Hecht, Chair

This dissertation examines the socio-spatial impacts of climate-related hazards and extreme weather events and associated responses in the Turtle Region of Trinidad & Tobago. The Turtle Region supports a growing eco-tourism industry centered on excursions to remote pristine beaches, hiking trails, waterfalls, and the annual migration of female leatherback turtles to lay their eggs on natal beaches. The Turtle Region also experiences rapid rates of coastal erosion and severe weather related events which trigger frequent flooding and landslides during the rainy season and extended drought during the dry season.

The first phase of the study consisted of a qualitative hazard impact assessment which examined the spatial distribution of impacts of extreme events using secondary data, site observations and focus groups with members of community-based organizations. The second phase examined the nature of impact and responses of households in different communities which are exposed to hazards such as coastal erosion and flooding events. This portion of the data collection consisted of a household survey conducted in three Turtle villages. The final phase explored the institutional challenges and opportunities to build resilience to extreme events through interviews with national and local government officials as well as community leaders.

The socio-spatial impact analysis of the Turtle Region revealed three primary hazards – landslides, flooding and coastal erosion - which affect the region collectively however there are distinguishable patterns of exposure and impact mostly affected by the location of the village. A majority of households indicated that their livelihoods were not affected by extreme events. Contacting others and rebuilding were the primary coping strategies employed by households, while migration does not appear to be a prevalent strategy. A large portion of households, although seemingly able to cope, make no adjustments in preparation for future events or shocks indicating perhaps that repeated experiences and familiarity with a particular risk over time translates to a normalization and acceptance of the risk.

Recommendations for developing low cost, high impact community-based adaptation projects which would applicable in other vulnerable coastal communities include public infrastructure improvements and maintenance, land-use set backs and controls, hard and/or soft mitigation structures, community education and awareness programs, developing NGO capacity and expanding mandates and community-based disaster training and response teams.

The dissertation of Tisha Terrianne Joseph Holmes is approved.

Leobardo F. Estrada

Randall D. Crane

Richard F. Ambrose

Susanna B. Hecht, Committee Chair

University of California, Los Angeles

2015

DEDICATION

I dedicate this dissertation to my village of family and friends who have my greatest gratitude, respect and love: To my husband Maurice who works hard to support our family; To our babies Troy and Melia who teach me to be present in every moment; To our parents Kerley, Maria and Clarence who generously give their time and love; To my friends Orly, Jonathan, Ankur, Erin, Ayanna-Rene, Ayanna, Kharis, Silvero and Sandy who give tireless encouragement and sage advice; To my super-mom society Hannah, Karla, Oh Mee and Lara who gave me precious time to work during the final stretch; To all of my family who have kept the faith every step of the way; And to my father Terrance who is dearly missed and lovingly remembered.

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Acronyms

AOGCM	Atmosphere-Ocean General Circulation Model
Ar4	IPCC Fourth Assessment Report
Ar5	IPCC Fifth Assessment Report
CANARI	Caribbean Natural Resources Institute
CARICOM	Caribbean Community
CCCCC	Caribbean Community Climate Change Centre
CEC	Certificate of Environmental Clearance
CEP	United Nations Caribbean Environmental Program
CEPEP	Community-based Environmental Protection and Enhancement Program
CPDC	Caribbean Policy Development Centre
DMU	Disaster Management Unit
ECLAC	United Nations Economic Commission for Latin America & the Caribbean
EMA	Trinidad & Tobago Environmental Management Authority
ENSO	El Nino-Southern Oscillation
GIS	Geographic Information Systems
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
LECZ	Lower Elevation Coastal Zone
NGO	Non-Governmental Organization
MSL	Mean Sea Level
ODPM	Trinidad & Tobago Office of Disaster Preparedness and Management
RCP	Representative Concentration Pathway
SIDS	Small Island Developing State
SPCZ	South Pacific Convergence Zone
T&T	Trinidad & Tobago
TCPD	Trinidad & Tobago Town & Country Planning Division
TDSD	Temperature Dependent Sex Determination
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
URP	Unemployment Relief Program
WMO	World Meteorological Organization

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PAPERS & PUBLICATIONS

Holmes, T. (2014). A review of climate change vulnerability assessments in Trinidad & Tobago. Trinidad & Tobago Institute of Marine Affairs. *Working Paper for Inter-American Development Bank, 1-22.*

Holmes, T. (2014). Integrated coastal zone management national stakeholder consultation report. Trinidad & Tobago Institute of Marine Affairs. *Report to ICZM Steering Committee, 1-30.*

Pincetl, S., Bunje, P. and Holmes, T. (2012). An expanded urban metabolism method: Towards a systems approach for assessing urban energy processes and causes. *Landscape Urban Plan, 107:3, 193-202.*

Pincetl S. and Holmes, T. (2010). Urban metabolism. Center for Sustainable Urban Systems, UCLA Institute of the Environment and Sustainability. *Report to California Energy Commission Public Interest Energy Research Program, 1-28.*

Holmes, T. (2010). Sa ou fe, se li ou we: Rebuilding governance in post-earthquake Haiti. *Critical Planning Journal, 17, 141-152.*

RESEARCH & TEACHING INTERESTS

- Climate change adaptation and socio-ecological resilience in coastal settlements.
- Integrated coastal zone planning and management in small island developing states.

- Environmental risk management and social vulnerability reduction in minority/low-income communities.
- Participatory action and community-based planning and engagement.

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2014-2015 **Counseling Assistant,** UCLA International Institute, Los Angeles, CA.
Advised matriculated and transferring students in the Global Studies major/minor and International Development Studies about program requirements, academic regulations and educational and career opportunities.

2014 **Trinidad & Tobago Institute of Marine Affairs – Biodiversity & Ecology Division,** Chaguaramas, Trinidad.
Assisted with the facilitation of community stakeholder engagement and consultation meetings for the Integrated Coastal Zone Management (ICZM) program; Analyzed community survey data from the Integrated Coastal Zone Management (ICZM) national stakeholder consultations.

2010 **UCLA Institute of the Environment and Sustainability**, Los Angeles, CA.
Conceptualized and reviewed literature on integrated human-energy flows, sinks, life cycle analysis and urban metabolism research frameworks; Contributed to the development of the project vision statement and production of research road map reports and academic publications; Conducted interviews with practitioners to support community outreach initiatives.

2005-2009 **Risk Analyst/Senior Risk Analyst,** Chartis Insurance (formerly AIG Environmental)**,** Philadelphia, PA.
Evaluated and underwrote complex pollution risks of commercial, retail, residential and manufacturing clients up to USD $500 million in revenues.

2002-2004 **Mellon Mays/Williams College Undergraduate Research Fellowship Program**, Williamstown, MA.
Developed independent research projects and papers: “Prospects for a Sustainable Development Transition in the Latin American and Caribbean Region”, “Problems of the Urban Poor in Developing World Cities”, “Hazardous Waste Management in Developing Countries” and “Out of Sight, Out of Mind: Analyzing the Superfund Law”.

2004 **Northern Berkshire Community Coalition**, North Adams, MA.
Developed a research strategy to examine the factors affecting community voting opinions and behaviors and methods of increasing voter participation; Assisted with coordination of community development and engagement activities.

2001 **Caribbean Network for Integrated Rural Development**, St. Augustine, Trinidad.
Developed educational materials on land degradation and desertification in Latin America and the Caribbean for a public awareness project for the Caribbean region under the UNCCD World Day to Combat Desertification.

Chapter 1 . Introduction

Statement of Problem

There is more certainty that the earth's atmospheric and ocean systems are warming at an unprecedented rate since 1850 and is a result of anthropogenic greenhouse gas emissions driven by land use changes, population and economic growth. Greenhouse gas emissions are the highest in history[1] (WMO, 2013). Gases such as carbon dioxide, methane, nitrous oxide and water vapor trap long-wave radiation in the troposphere and increase atmospheric temperatures. This enhanced "greenhouse effect" is predicted to have widespread impacts on sensitive humans and natural systems on all continents and across oceans including the frequency and intensity of extreme weather events, loss of snow and ice, negative changes to crop yields, alternations in hydrological cycles, shifting geographic ranges of species, migration patterns, abundances and species interactions and increasing sea levels (IPCC, 2001, 2007b, 2014; UNFCCC, 2008).

The very likely contribution of mean sea level rise and increased extreme coastal high water levels, coupled with the likely increase in tropical cyclone maximum wind speed is a specific issue for tropical small island developing states (SIDS). SIDS have a range of physical, social, environmental and economic characteristics that make them vulnerable to natural hazards at rates and intensities above those found elsewhere around the globe. Their small size and isolated, sensitive environments constrain their capacity to absorb shocks and as a result, the effects and damage of hazardous events are often disastrous (Kaly, Pratt, & Howorth, 2002; Kelman &

[1] According to the WMO Greenhouse Gas Bulletin, global-average atmospheric concentrations of carbon dioxide rose to 389 pp in 2010 (an increase of 39 per cent compared to pre-industrial times), methane to 1 808.0 ppb (158 per cent) and nitrous oxide to 323.2 ppb (20 per cent).

West, 2009; Pelling & Uitto, 2001). Although categorized by the IPCC as a global “hot spot” for climate impacts and arguably one of the most vulnerable segments of the global geography to extreme events, limited attention has been paid to examining the social impact and responses to climate change variability at the local level in SIDS (Gero, Meheux, & Dominey-Howes, 2011; Tompkins, 2005).

There is much to understand about community responses to disaster events, social vulnerability at the local level and the interaction of biophysical and social conditions in the context of disasters for several vulnerable localities (Cutter, 2001; Cutter et al., 2008; Cutter, Boruff, & Shirley, 2003; Flint & Luloff, 2005). Disasters are typically considered as infrequent and temporary disruption of local conditions. However, the entrenched land use decisions and historical patterns of development have created spatially and socially vulnerable settlements so dependent on critical infrastructure and ecosystem services, that the ability to return to previous conditions of normalcy after a hazard event more difficult to achieve for SIDS. With the impending uncertainties associated with a changing climate, there is a need to critically examine the existing disaster risk reduction approaches due to new risks brought by climate change and opportunities to adapt (Birkmann & von Teichman, 2010; Mercer, 2010; Prabhakar, Srinivasan, & Shaw, 2009; Thomalla, Downing, Spanger-Siegfried, Han, & Rockström, 2006).

The ability to understand the prevalence, location and magnitude of natural hazards has advanced considerably along with capabilities in forecasting and warning systems, however, the escalating patterns of losses particularly in the developing world present new avenues of inquiry. There is a need for reliable and systematic empirical data on climate related disasters to assess the short and long term socio-economic and environmental impacts at various scales in order allow for local level evaluation of patterns of risk such as interactions of hazards, triggering of secondary hazards and small scale disasters in order to inform policy (Sperling & Szekely, 2005; van Aalst, 2006). As more attention is also paid to new and enlarged risks from natural hazards and evidence of a shifting climate regime continues to grow, a new synthesis of the varied dimensions of hazards and disasters is needed to integrate and embed these studies within broad environmental equity and sustainable development goals. (IPCC, 2012a; O'Brien, O'Keefe, Rose, & Wisner, 2006; White, Kates, & Burton, 2001). Moreover, understanding the nature of coping and adaptive mechanisms employed by exposed populations in SIDS locally can enable the development of better targeted national and regional climate adaptation policy mechanisms and strategies.

This study seeks to engage and integrate the community-based disaster risk management and climate change adaptation fields to evaluate the local dynamics which mediate community and household level vulnerability and responses to hazards that can be exacerbated by climate change in the small island developing state of Trinidad & Tobago in the Caribbean. The Turtle Region of Trinidad was selected as the case study to explore the various dimensions of community risk and resilience to extreme events. Largely undeveloped and rich in endemic forest and coastal flora and fauna, the Turtle Region supports an eco-tourism industry centered on the annual migration of female leatherback turtles to lay their eggs on natal beaches. The Turtle Region also experiences rapid rates of coastal erosion and severe weather related events which trigger frequent flooding and landslides during the rainy season and extended drought during the dry season.

Much development in the Turtle Region occurs without much over sight or adherence to setback distances or environmental impact assessments. Residential development in the region is regulated through the Northern Range Hillside Development Policy[2]. However, little enforcement action occurs against the owners of illegally constructed building and several buildings built prior to 2000[3] do not have mitigation structures to minimize environmental impacts. Deforestation due to slash and burn cultivation on state lands and/or illegal occupation by agricultural and residential squatters leave saturated soils unconsolidated and exposed, leading to landslides during heavy rainfall events and increased sediment loads in rivers (Ramlal & Baban, 2008). Land use mismanagement and clearance of coastal vegetation reduce buffering action against erosion and inundation on the coast. Quarrying activities which began in the 1970s, are increasing in the area and associated with poor land use and degradation of the landscape. Non-rehabilitated, illegal and abandoned quarries present an array of environmental problems include loss of bidoversity, dust and noise pollution, siltation of rivers and excessive surface run-off and flooding events (Planviron & Touristics, 1999). Heavy rainfall events have triggered several flooding and landslide events within the past 10 years. These events triggered road blockages which marooned villages for extended periods, loss of property and livelihoods and even loss of life in some cases (Dowlat, 2014; Fraser, 2013; Seelal, 2005; Sorias, 2010). Rivers emerging onto beaches also flood annually and lead to considerable periods of erosion and threaten the viability of nests as well as beachfront hotels and homes (Moe, 2012).

[2] Development will not be permitted above the 300 foot contour, forestry zones, slopes in excess of ten degrees and on good agricultural lands with land capability classes I to III.

[3] Legislation mandating compliance with regulations of EMA came into force in 2000.

The premise of the study is based on the reality that exposure to climate-related hazards negatively impact the viability of coastal communities and lead to an amplification of climate change risk over time. Ideally, national climate adaptation and local disaster response mechanisms should be integrated to enable communities to respond and recover from extreme events. However, low-income, rural communities are often disengaged from the national political and economic architecture and rely on local institutions to respond to their needs. Understanding the nature of risks, vulnerabilities and responses at the household and community scales can enable local institutions to develop targeted adaptive options which can strengthen community resilience. Lessons and best practices can also be transferred to other vulnerable localities facing similar threats associated with a changing climate.

Organization of Dissertation

The dissertation begins with a survey of the scholarly literature on hazards and vulnerability research with a focus on political ecology perspectives in Chapter 2. Chapter 3 surveys the situational context of the vulnerability of sensitive ecological systems and critical social sectors in Small Island Developing States to climate variability and extreme events. Chapter 4 explores the research and policy contexts of the Caribbean Region as a critical case which demonstrates the intersecting dimensions of geographic, economic and social vulnerability to climate-related hazards and disasters. The empirical gaps in social science and policy research in the Caribbean are highlighted and provide the context for the main research questions directing the study and analytical framework which are elaborated in Chapter 5. Chapter 6 outlines the mixed methods and participatory approaches utilized to collect spatial and social data and addresses limitations of the research design. Chapter 7 outlines the socio-ecological context in Trinidad and features the Turtle Region in greater detail. Chapter 8 presents the findings on spatial and social impacts as well as adaptive responses to extreme events. The dissertation concludes in Chapter 9 with policy recommendations for pursuing pathways towards building a climate resilient Turtle Region and suggestions for future research.

Chapter 2 . Literature Review

Scientific research on natural hazards engages in a process of systematic observations, monitoring and prediction of the dynamic processes operating within natural systems (Douglas, 2007). The contributions of the scientific approach to hazards are important for clarifying the magnitude and frequency and geophysical processes of events, identifying and zoning hazardous areas, provide predictions for warning against impending events which have implications for emergency, land use and mitigation planning (Godschalk, Brody, & Burby, 2003; K. Smith, 2013). However, this research is often deterministic and do not address: 1. The ways in which systems amplify or attenuate the impacts of hazards; 2. The distinctions among exposed subsystems and components that lead to significant variations in the consequences of hazards and 3. The role of political economy, social structures and institutions in shaping differential exposure and consequences (Turner II et al., 2003). While the geophysical setting describes physical processes to which threatens a population in order to identify effective mitigation strategies, technocratic and engineering attempts to control hazards without attention to the role of citizens, social, economic and political factors at play are often ineffective (Blaikie, Cannon, Davis, & Wisner, 2014; Montz & Tobin, 2011).

In response to the 'Hazard as agent' theoretical and empirical gaps on understanding the role of human action in creating risk and disasters, 'Human as agent' approaches arose dramatically between the 1950s and 1980s to provide a more balanced consideration of the social context to situate the cultural, political, demographic and economic factors that influence the interaction of human activity with environmental systems (Hewitt, 2014; Mileti, 1999) . The notion of hazards and disasters as predictable and external events were replaced by the interpretation that they emerged from interactions between humans and their environments, involving different combinations of physical processes and human activities that create a variety of risks (J. K. Mitchell, Devine, & Jagger, 1989). Since the standard methods of operations and assumptions within a society, can increase or reduce susceptibility to major losses, humans hold a great deal of culpability for shaping the underlying social forces and processes that lead to negative outcomes (White et al., 2001). As (Palm, 1990) succinctly outlines:

> "Society and environment are inextricably intertwined. One could argue that there are no truly natural disasters, that all disasters are at least partly the product of the way society treats the physical event. It is the structure of society that permits or even amplifies the effects of normal climatic, geophysical, or biological variability, sometimes converting this normal variability into what becomes a disaster" (16).

The main premise asserts that the presence of hazards in the environment is natural, however disasters are not[4]. Social scientists criticized the 'Hazard as agent' approach to reducing human susceptibility to hazards, since no 'behavioral fixes' occurred in tandem[5]. Although understanding the geo-physical mechanisms of hazards is important, focusing on the physical characteristics of hazards did not explain the underlying reasons of why the hazard caused an associated disaster (Bull-Kamanga et al., 2003; Cannon, 1994).

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[4] More simply, if no people or property is affected, the impact of a hazardous event will not produce a disaster.

[5] For example, the dams and constructed river channels may have reduced the number of floods but these fewer floods resulted in even greater damages because populations continued risky activities.

The role of human activity in the generation, exacerbation and exposure of hazards initially evolved within the field of Human Ecology. Scholars questioned the 'natural' aspect of disasters by emphasizing both the physical aspects of hazards and the ways in which it impacted and was influenced by human capabilities and response capacities (Blaikie et al., 2014; Burton, Kates, & White, 1978; Klein, Nicholls, & Thomalla, 2003; Mileti, 1999). Political ecologists are equally critical of the Hazard as agent's deficiency in addressing socio-political contexts and tackled natural-hazards research by examining hazard events as triggers within the workings of a broader socio-economic system. However, political ecologists guided by neo-Marxian structuralist, post-structuralist and post-colonial and feminist theories, sought to emphasize the historical analysis on the more deeply rooted and chronic imbalances of power which limits individual action, viewing the relationships between hazards and culture and the empirical scientific evidence as discursive social constructs (Pelling, 1999, 2003). It complemented the body of work produced by the political economy school by advancing broader concerns of marginality, pressure of production on contested resources and plurality of positions and interests guide political ecology analyses that socio-economic systems produce unequal access to opportunities and unequal exposure to risks. Issues of justice, inequality, poverty, exploitation and the reproduction of poverty are at the core of political ecology analysis of hazards and disasters. As a result, more attention is focused on addressing levels of vulnerability to these hazards and opportunities to recover from impact (McEntire, 2004). This concept emerged from the notion that focusing on the physical nature of perturbations alone did not build a complete story of the responses of and impacts on social groups, ecosystems and places (Cutter & Finch, 2007; Liverman, 2001; Sanderson, 2000).

Pelling (1999) applied a political ecology analytical framework to examine the linkages between Guyana's colonial experience and post-colonial modernization projects with the creation of coastal hazards such as erosion and accretion. Unlike typical hazard analysis studies which looks at social relations in the context of a single event, his study conceived the flood hazard as ongoing, everyday state in which extreme and episodic flood risks were embedded in society. The failure of the coastal political economy to produce inputs required for its maintenance, made the coastal areas vulnerable to coastal hazards and the potential impacts of climate change. He identifies the capacity of individual actors and social institutions as rooted in the agent's ability to compete for access to rights, resources and assets which in turn affects the ability to adapt to hazard stress. Also important is the role of institutions across different scales of influence, differential access to information and resources as well as the legal rights and responsibilities. In Guyana, drainage, construction of flood control and permanent settlement of the coast formerly occupied by low lying mangrove was in pursuit of the historical, political and economic imperatives between the 17^{th} and 20^{th} centuries operating within the national global capitalist productive systems. He highlights the fragility of this transformation through the resurgence of the coast a hazard and as levels of human resilience to environmental and economic stresses fluctuate. He identifies neighborhoods characterized by high vulnerability to flooding are mostly low income, agricultural livelihoods, rental and squatter households where leadership from community based organizations or patronage based on local authority representation was absent. Poorly maintained hazard management infrastructure and drainage system are also a key component to increasing vulnerability of residential areas occupying the coastal plain. Limitations identified in the political-economy call for reform of the institutional framework in which decision making for environmental management is conducted.

This perspective implies that disasters a preventable, pointing to the accountability of people, processes and institutions that increased the susceptibility to natural event or have a part to play in preventing or mitigating its impacts. People are no longer hapless victims but actors capable to varying degrees to cope or avoid the event, as such their resources become central to recovery (Blaikie, 2002). Shifting the attention to understanding the ways in which social systems generate unequal exposure to risk by making some groups, societies and individuals more prone to hazards than others, political ecologists emphasized questions of class, gender and ethnicity as they relate to the principal systems of power which are rooted in national and international economic and political systems that create inequality of risk. These social structures are also identified to affect the preparedness and mitigation levels through allocation of scientific research, resource allocation and type and extent of technical preparation. Harm associated with hazards were not uniquely explained or solely dependent upon the geophysical processes that initiate damage. Social and economic activities and structures operated to affect vulnerability and the damage caused while also being influenced by external forces (Wisner, 1993; Wisner, Gaillard, & Kelman, 2012).

The focus of political economy analysis is primarily on the meso and macro scales. Consequently, local agency has traditionally been excluded from analysis due to the emphasis on external environment forces or social vulnerability (Burton et al., 1978). The political ecology lens on vulnerability analysis involves the analysis of the means by which some people live at the expense of others, shedding light on why poor populations often occupy marginal, less productive and hazardous areas. This study adopts a human systems political ecological lens to explore the environmental and social dimensions of risk, responses and resilience. From this perspective the environment and technology are socially constructed outcomes of social relations between people and their environment. It acknowledges the internal complexity of differential and diverse populations interacting with dynamic physical environments and socially structured, political and economic institutions (Oliver-Smith, 2009). It focuses on the complexities of social vulnerability and the role of communities as agents of change and vulnerability reduction has responded to the gap including attention to individual experiences, local knowledge, participation, action and control.

Chapter 3 . Situational Context

Climate change and extreme events

Climate extremes can be categorized into two groups – those based on climate statistics – e.g. extremes of very low or very high daily temperature or heavy daily or monthly rainfall; and more complex event driven extremes – e.g. sea level rise, long-term droughts, floods, hurricanes which do not necessarily occur every year and vary in terms of intensity (Easterling et al., 2000). The Intergovernmental Panel on Climate Change (IPCC) adopts the former category when defining an extreme event as an "an event that is rare within its statistical reference distribution at a particular place" (IPCC, 2001) i.e. driver events which occur at the tail ends of the distribution of climate statistics. Considering a given probability distribution of occurrence for any climactic parameter, it is assumed that increases in mean values as well as increased variance in amplitude, will lead to more frequent and more intense extreme events at one tail of the distribution. Additionally, extremes at the minimum end of a given parameter will disappear while historically unprecedented intensities will arise at a maximum (Jentsch & Beierkuhnlein, 2008).

Complexities arise from the fact that the extreme nature of a climatic event is context-dependent in terms of the historical occurrences climate record and the type of impact, effect and outcome in ecological and human systems which experienced events in the past (M. D. Smith, 2011). A more intuitive definition accounts for the unusual or profound effect on the system in comparison to normal variability (M. D. Smith, 2011). As such, this study generally defines an extreme event which is either, "notable, rare, unique, profound, or otherwise significant in terms of its impacts, effects or outcomes" (Sarewitz & Pielke Jr., 2001) which acknowledges that a complex set of attributes such as the rate of occurrence, its intensity and severity of impact, temporal duration and timing and spatial structure can influence the manner in which the event is actualized (Planton, Deque, Chauvin, & Terray, 2008; Stephenson, 2008).

Much of the social and economic costs are predicted to result from shifts in the frequency and severity of extreme events associated with a changing climate (Huber & Gulledge, 2011). The geographic and scalar proliferations of extreme events vary and precise tipping points that will trigger abrupt and irreversible change remain uncertain. Since climate change is defined by changes in mean conditions over the long-term, it may be difficult to make direct casual links between a changing climate and an isolated weather or climate related extreme event. Although a particular weather event is not directly caused by a single risk factor, the probability of occurrence can increase depending on which risk factors are operating. For example, a warmer atmosphere can hold more moisture and thus generate more intense rainfall and storms which may mean over the longer term trends in climate variability the frequency and intensity of these types of events can increase[6] (Meehl et al., 2000).

The 2007 IPCC Ar4 dedicated special attention to "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation". The report projects that under emissions scenarios A1B [7]and A2[8] a 1 in 20 year hottest day is likely to become a 1 in 2 year event by the

[6] The IPCC Ar5 did not find strong evidence that tropical storms were increasing in frequency or intensity with a changing climate.

[7] A1B = Global population peaks in mid-century; rapid economic growth, but with balance of fossil and non-fossil energy sources.

end of the 21st century in most regions[9]. Under B1[10] emission scenario, a 1 in 20 year event would likely become a 1 in 5 year event[11]. It is likely that the frequency and intensity of heat waves and heavy precipitation will increase in the 21st century particularly in the high latitudes and wet tropical regions. Based on the range of emissions scenarios, a 1 in 20 year annual maximum daily precipitation amount is likely to become a 1 in 5 to 1 in 15 year event by the end of the 21st century in many regions. Average tropical cyclone maximum wind speed is likely to increase, although this may not occur in all ocean basins. It still remains uncertain whether the global frequency of cyclones will change (Jentsch & Beierkuhnlein, 2008). There is medium confidence that droughts will intensify in the 21st century in some seasons and areas[12], due to reduced precipitation and/or increased evapo-transpiration. It is very likely that mean sea level rise will lead to upward trends in extreme coastal high water levels in the future. There is high confidence that locations currently experiencing adverse impacts such as coastal erosion and inundation will continue to do so in the future due to increasing sea levels. There is also high confidence that changes in heavy precipitation will affect landslides in some regions.

[8] A2 = Population still increasing in 2100 with only modest regional convergence; heterogeneous world with slow economic development and technological change.

[9] Except in high latitudes of Northern Hemisphere where it is likely to become a 1 in 5 year event.

[10] B1=Global population peaks in mid-century; rapid change of a service and information economy with lower material intensity; emphasis on sustainability.

[11] 1 in 10 year event in Northern Hemisphere latitudes.

[12] Regions include southern Europe and Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil and southern Africa.

Globally, changes in extreme weather events attributed to human influences have been observed since 1950, including decreasing number of cold days and nights, increasing warm daily temperature extremes and the frequency and intensity of heat waves, increases in the incidence of drought and drought related wildfires, increases in extreme high relative sea levels and an increase in the number of heavy precipitation events (Allan & Soden, 2008; IPCC, 2001; Ismail-Zadeh, J., Kijko, Takeuchi, & Zaliapin, 2014; Klein & Nicholls, 1999). The apparent increase in these types of events and growing proportion of losses has raised the alarm on the vulnerability human settlements face to climatic variability (Changnon, Pielke Jr., Changnon, Sylves, & Pulwarty, 2000; Leiserowitz, Mabach, Roser-Renouf, & Hmielowski, 2012).

Extreme event impacts, losses and trends

The global reinsurance company Munich Re estimates that although earthquakes claim the most lives, weather and climate related hazards have the most significant impact on overall losses and claims for insured losses (MunichRe, 2015). There is also evidence that insured losses from extreme climate events are increasing, due not only to increases in insured infrastructure but also to recent changes in weather and climate extremes (Beniston et al., 2007). In 2010, one of the warmest years on record, the second-largest (after 2007) number of recorded natural disasters and the fifth greatest economic losses, 874 weather and climate-related disasters resulted in 68,000 deaths and $99 billion in damages worldwide (Huber & Gulledge, 2011). Recent extreme events caused billions of dollars in economic and property damages and loss of life. In the first two weeks of August 2003, 18,000 people died in what has been categorized as Europe’s hottest summer since AD 1500[13] (Black, Blackburn, Harrison, Hoskins, & Methven, 2004; Deschenes & Moretti, 2009; Kovats, Wolf, & Menne, 2004; Stott, Stone, & Allen, 2004). The July-August 2010 floods in Khyber Pakhtunkhwa Province in Pakistan were the result of anomalous and extreme rainfall in the region and caused catastrophic losses to life, property, infrastructure and agricultural land[14] (Hashmi, Siddiqu, Ghumman, Kamal, & Mughal, 2012; Houze Jr., Rasmussen, Medina, Brodzik, & Romatschke, 2011; Khandekar, 2010; Lavy, 2010; Warraich, Zaidi, & Patel, 2011; Webster, Toma, & Kim, 2011). Before ravaging the mid-Atlantic, Northeast and Ohio Valley regions of the United States as a hybrid post-tropical cyclone and winter superstorm in October 2012, Hurricane Sandy triggered severe floods and mudslides, claiming the lives of 80 people in six Caribbean counties, particularly in Cuba where nearly 200,000 homes were damaged[15] and an estimated 1.8 million affected in Haiti, the poorest nation in the Americas[16] (Neria & Shultz; UNDP, 2012; Watts, 2012). In the United States, the hurricane merged with a winter jet stream and associated cold front to become a 1,100 mile wide system. Sandy's heavy rains[17], 90-100mph winds and the associated storm surges triggered

[13] Persistent ant-cyclonic conditions over the region, lack of cloud cover and dry land surfaces contributed to the extreme temperatures and lack of precipitation. Night-time temperatures exceeded the climatological mean daily temperatures. Averaging over each month the temperature anomalies were +4.2degree Celsius in June, +3.8 degree Celsius in August and almost +2 degree Celsius in May and July. The temperature anomalies were most extreme in France and Switzerland, although maximum temperature records were broken in many parts of Europe. France experienced the highest temperatures for 50 years. Paris experienced the highest nighttime temperatures ever recorded on 11 and 12 August (25.5^{o}C), and death rates more than doubled.

[14] The floods affected an area of about 160,000 km^2 (one fifth of the country), claiming about 1,985 lives, damaging around 1.5 million houses, wiping out cropped area of more than 17 million acres, displacing a population of about 20 million and resulting in economic loss of PKR 10 Billion.

[15] Substantial damage was also sustained by agricultural sector and critical infrastructure.

[16] Estimated economic losses ranged from $5 million in Jamaica to $2 billion in Cuba.

[17] In the Mid-Atlantic tropical moisture combined with subfreezing air to bring heavy, early season snowfall in West Virginia and North Carolina.

widespread flooding in Lower Manhattan, decimated towns along the New Jersey coast and left more than 8 million without power from Virginia to Maine to Michigan (Halverson & Rabenhorst, 2013). Although only 125 died in Sandy's wake, thousands were displaced, 570,000 buildings including 200,000 homes were destroyed, the region's energy and food distribution, communication and transportation systems were crippled and resulted in an estimated $50 billion in damages[18] (Abramson & Redlener, 2012; Porter, 2013). Super Typhoon Haiyan[19], the most powerful typhoon to make landfall to date, struck the Philippines, Vietnam and neighboring areas in November 2013 (Mas et al., 2014). The storm surges caused by Haiyan inundated the entire coastal areas of Tacloban and Palo in Leyte, Philippines. Over 6,000 people lost their lives, 16.1 million people were affected and estimated damages to housing, infrastructure and agriculture was around $10 billion USD (Mori et al., 2014). Flooding in South and East Germany was one the region's largest floods in the past two centuries and the most costliest natural disaster in 2013, with estimated economic damages of $12.9 billion USD (Debarati Guha-Sapir, Hoyois, & Below, 2014). The Australia summer 2012/2013 area-averaged surface air temperature was the hottest since national records began in 1910. Temperature records were broken on daily and monthly timescales (S. Lewis & Karoly, 2013)

Much of the social and economic costs are predicted to result from the shifts in the frequency and severity of extreme events (Huber & Gulledge, 2011). The question of whether these events are impending signs of a new norm under a changing climate or a less ominous a cyclical

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[18] Second only to Hurricane Katrina as the nation's costliest natural disaster.

[19] Classified as a Super Typhoon based on its maximum sustained 1 min surface wind speed of 315 km/hour which is equivalent to a strong Category 5 hurricane of the Saffir-Simpson scale.

occurrence which can pass in a few years remains unclear. However, these disasters speak to the impending challenges human settlements face at various scales and across sectors. Extreme events will have greater impacts on sectors which have closer links to climate, such as water management systems, agriculture and food security, forestry, health and tourism. The impacts of the events although wide ranging acutely impact the most vulnerable sectors of society and sensitive ecosystems (Cutter et al., 2006; Fraizer, Wood, Yarnal, & Bauer, 2010). Understanding the range of possibilities for impact of extreme weather events, whether triggered by a changing climate or not, exposes the explicit and hidden vulnerabilities of human-ecological systems as well as the barriers to recovery.

Research on extreme events and their impacts on human populations wide ranging in its geographic and disciplinary orientations (Bell, Sloan, & Snyder, 2004; Beniston et al., 2007; Changnon, Changnon, & Hewings, 2001; Deschenes & Moretti, 2009; Planton et al., 2008; Retchless, Frey, Wang, Hung, & Yarnal, 2014; Sisson, Pericchi, & Coles, 2006; Williams, Tom, Riley, & Wehner, 2014). The very likely contribution of mean sea level rise and increased extreme coastal high water levels, coupled with the likely increase in tropical cyclone maximum wind speed is a specific issue for tropical small island developing states (SIDS). SIDS have a suite of physical, social, environmental and economic characteristics that make them vulnerable to natural hazards at rates and intensities above those found elsewhere around the globe. They also are considered to have high internal resilience and a long history of coping with environmental variability (Hay, 2013) Although categorized by the IPCC as a global “hot spot” for climate impacts and arguably one of the most vulnerable segments of the global geography to extreme events, limited attention has been paid to examining the spatial and social impacts and responses to extremes in SIDS (Barnett & Campbell, 2010).

Climate change vulnerability and SIDS

SIDS are typically recognized for their small size, tropical climates, insular economies based on limited ranges of products and markets (e.g. tourism and agriculture), high levels of biological diversity and endemism and fragile natural resource bases (Hay, 2013; Kaly et al., 2002; Kelman & West, 2009; Mimura et al., 2007; Nurse et al., 2001; Pelling & Uitto, 2001). These islands represent self-contained isolated exotic entities that connect inhabitants to the elements of physical nature in vibrant culture and customs. However, the romanticism of the islands' peace pristine beaches and historical and cultural heritage advanced by the tourism industry often obscures the inherent reality of remoteness, isolation, marginality and vulnerability faced by local populations.

A review of past and present trends of climate and climate variability indicates that temperatures have been increasing by as much as 0.1 degree Celsius per decade and sea level has risen by 2 mm per year in regions where small island states are located. Analysis of observational data for these regions suggests that increases in surface air temperatures in the Pacific Ocean and Caribbean Sea have been greater than global rates of warming. Observational evidence also suggests that much of the variability in the rainfall record of Caribbean and Pacific islands appear to be closely related to the onset of El Nino-Southern Oscillation (ENSO), the Inter-Tropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ) and will continue on a seasonal and decadal time scale (Nurse et al., 2001). With respect to extreme events, Atmosphere-Ocean Global Climate Models (AOGCM) project that by the 2050s and 2080s there will be increased thermal stress during summers as well as more frequent droughts and floods in all four tropical ocean regions where small island states are located. These projections imply that these regions are likely to experience more floods during wet seasons and increased droughts during dry seasons. As a result of variations in geography and weather patterns[20], climate change will not be felt the same way by all SIDS (Munro, 2010). The IPCC indicates that Mediterranean countries are very likely to face more drought episodes in the future, the Caribbean will experience low rainfall[21] (Kelman & West, 2009) and the conversely, the intensity of rainfall in the Indian Ocean is expected to rise (Munro, 2010). Also although considered one of the most significant climate change threats to SIDS, there is no consensus on how climate change will affect the frequency and intensity of El Nino events or tropical cyclonic activity (IPCC, 2012b).

Although small island states are not a homogenous group, they share similar characteristics which increase their vulnerability to projected impacts of climate change and constrain them in their path to sustainable development including their small physical size and insular economies, competing and intensifying land-uses, dependence on sensitive and fragile natural resource bases and limited infrastructure and institutional capacities (Kelman & West, 2009; London, 2003; Meheux, Dominey-Howes, & Lloyd, 2007; Pelling & Uitto, 2001; UN-OHRLLS, 2013).

[20] E.g. Weather is shaped by inter-annual seasonal changes in rainfall, trade winds, semi-permanent sub-tropical high pressure belts, ENSO variations.

[21] Projected change in precipitation by 2100 relative to 1961-1990 could range from -49.3% to +28.9 %.

Overall, SIDS account for less than 1% of carbon dioxide emissions (Julca & Paddison, 2010; UNEP, 2008) because they are so small and most do not have extensive forests but face a disproportionate level of vulnerability to climate change (Kelman, 2010; Wong, 2010). Large proportions of populations in SIDS live in the low elevation coastal zone (LECZ)[22] and are physically, socially and economically vulnerable to climate change induced hazards (See Figure 1). (McGranahan, Balk, & Anderson, 2007) estimate that for small island states 6 million people live in the 58,000 km^2 LECZ which consists of 13% of the population and 16% of total land area. Coastal ecosystems in SIDS have been severely degraded as a result of population growth, increasing urbanization, industrialization and tourism (Pernetta, 1992; Redclift, Manuel-Navarrete, & Pelling, 2011). This degradation reduces long-term resilience of these systems to climate variability and extreme events, disrupting ecosystem services and the livelihoods dependent upon them (Duxbury & Dickinson, 2007; Kesavan & Swaminathan, 2006). Although predicting clear trends of sea level changes is limited by paucity of observational data, climate extremes pose serious risks to the geophysical and ecological processes as well as livelihoods and economies of SIDS on local and national scales because they are often reliant on critical coastal and marine resource bases. The following section reviews these dimensions broadly for the purposes of highlighting particular challenges this study intends to examine in the Turtle Region.

[22] Defined as the contiguous area along the coast that is less than 10 meters above sea level.

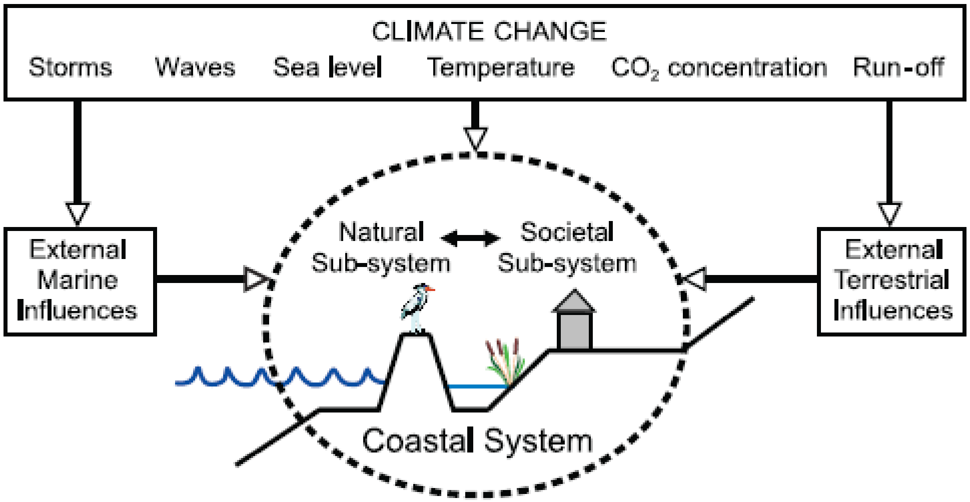

Figure 1. Climate Change and the Coastal System[23].

Ecological impacts

The emergent ecological responses to climate change can manifest as distributional shifts in zonation patterns and bio-geographical ranges, changes in species compositions, diversity and community structure as well as changes in primary and secondary production (Harley et al., 2006; Nurse et al., 2001). Synergistic and cumulative effects of various environmental and human induced stressor are causing extinctions and altering marine biodiversity (Fuentes, Limpus, & Hamann, 2011; Gilman et al., 2010). For example, sea turtle reproduction and nesting locations and activities are particularly vulnerable to climate hazards such as increases in air and sea surface temperature, sea level rise and altered cyclonic activity. Additionally, climatic conditions are likely to affect food availability which can have indirect effects on fitness and reproductive performance (Mazaris, Kallimanis, Sgardelis, & Pantis, 2008).

[23] *Note*. From: Coastal systems and low -lying areas by Nicholls, R. J., P. P. Wong, V. R. Burkett, J. O. Codignotto, J. E. Hay, R. F. McLean, S. Ragoonaden and C. D. Woodroffe (2007) in Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. J. Hanson (eds). Cambridge, UK, Cambridge University Press: 315-356. Copyright 2007. Reprinted with permission.

Climate changes may have multiple and simultaneous impacts on marine turtle populations' survivability and phenotypical characteristics. Reproductive success of egg burying species like sea turtles depends on the hydric and thermal stability of the nest environment (Pike, 2013; Tomillo et al., 2011). Marine turtles are ectothermic species where their life history traits, behavior and physiology are strongly influenced by environmental temperature (Fuentes et al., 2011; Fuentes & Porter, 2013) and exhibit Temperature Dependent Sex Determination (TDSD) where the phenotypic sex of offspring is correlated with the nest (Kamel & Mrosovsky, 2006) temperatures during the middle third of the embryo incubation period (Hawkes et al., 2013; Kamel & Mrosovsky, 2006). Additionally, the temperature of the sand that surrounds sea turtle eggs affects egg development rates, health, success and phenotype of hatchlings (Fuentes & Cinner, 2010; Fuentes et al., 2011; Tomillo et al., 2011; Witt, Hawkes, Godfrey, Godley, & Broderick, 2010). Successful incubation of sea turtle eggs occurs between a range of 25 to 33 degrees Celsius[24] (Fuentes, Hamann, & Limpus, 2010)(Tomillo et al., 2014). Primary sex ratios in sea turtles are usually female biased however there is also seasonality in sex ratios as temperatures fluctuate during nesting seasons, with males produced during cooler periods and females produced when temperatures rise. High temperatures and dry substrates are unfavorable for successful egg development and hatchling quality (Tomillo et al., 2011). As a result, the long term survival is dependent on a sufficient range of incubation temperatures that ensures both males and females are hatched (Hays, Broderick, Glen, & Godley, 2003). Temperature of the sand also affect the ability of hatchlings to emerge from the nest, so while higher temperatures

[24] A 50:50 sex ratio is produced at a pivotal temperature, of close to 29 degrees Celsius while above this temperature females are produced and below this temperature more males are produced.

produce female biased clutches, mortality in the hatchlings are also higher (Tomillo et al., 2014; Tomillo et al., 2011).

Another primary effect of climate change to nesting beaches is sea level rise where higher water levels will decrease the availability of suitable nesting sites and/or alteration of nesting beaches and egg mortality (Fuentes et al., 2011; Schoeman, Schlacher, & Defeo, 2014; Witt et al., 2010). Successful reproduction will be threatened without access to sandy beaches which are conducive to egg incubation. Up to half of the current nesting areas could be lost to predicted sea level rise, especially in island environments where retreat options are limited or in densely populated coastal zones. Incubating clutches could also be at risk from flooding associated with rising water tables as the sea level rises, storm activity, surges, wave action and sand wash out events (Witt et al., 2010).

Marine turtles have lived on this planet for over 175 million years and were exploited extensively for hundreds of years for sustenance and trade (McClenachan, Jackson, & Newman, 2006). Now most of these ancient species are listed as in danger or critically in danger of becoming extinct[25] (Donlan, Wingfield, Crowder, & Wilcox, 2010). However, throughout the millions of years that sea turtles have existed, they have demonstrated a biological capacity to adapt. Different species of turtles are affected by environmental conditions and as a result can respond variably to climate forcing on regional turtle populations (Tomillo et al., 2011; Witt et

[25] Six of the seven species of turtles are listed as endangered or critically endangered by the International Union for Conservation of Nature.

al., 2010). Sea turtles also have the ability to colonize new nesting sites in response to unsuitable conditions, shifting their nesting sites and developing new migratory routes (Fuentes & Abbs, 2010). However, there is uncertainty regarding, the likelihood that turtles will be able to evolve rapidly enough to keep pace with increasing temperatures, adopt behavioral modifications such as relocation of nesting dates, migration to cooler latitudes, which has implications for the survivability of or the possible extinction of the species (Janzen, 1994). While shifts in nesting phenology are thought to be insufficient to effectively counteract the effects of increasing temperatures (Fuentes et al., 2010), other researchers have called for the preservation of natural beach vegetation to maintain appropriate thermal coastal habitats (Kamel & Mrosovsky, 2006).

The potential effects of climate change cannot be considered in isolation from existing threats to turtles and their habitat. Turtles also face anthropogenic pressures which can decrease their resilience and capacity to adapt[26] (Allison et al., 2009; Campbell & Lagueux, 2005; Gilman et al., 2010; R. Lewison, Freeman, & Crowder, 2004; R. L. Lewison & Crowder, 2007; Roe, Clune, & Paladino, 2013; Saba, Spotila, Chavez, & Musick, 2008). The implications of climate change for engendered species such as marine turtles extend beyond the direct and indirect effects of synergistic and cumulative interactions of ecological stressors which already threaten to their declining populations (Fuentes et al., 2011; Gilman et al., 2010). The loss of such a keystone species may have cascading impacts within the marine ecosystem, production cycles and food webs. SIDS communities which are dependent on these species may also suffer as a result of lost revenues, livelihoods and intrinsic cultural value.

[26] Coastal squeeze through development, nesting beach degradation, feral predation, poaching, direct harvesting of turtle and eggs, incidental by catch in fishing nets) and pollution.

Human Settlement Impacts

Projected rising of average sea levels threaten the low-lying islands[27] and Pacific atoll nations[28] and could result loss of beaches, land, infrastructure and in the most extreme cases, the disappearance of whole islands[29] (Barnett, 2009; Hay, 2013). In most SIDS, narrow coastal plains provide attractive locations for human settlements and a variety of infrastructure – social services, tourism facilities, airports, port facilities, roads and vital utilities – to support economic and social needs. With the projected rate of sea-level rise and changes in the patterns of extreme events such as storms and coastal flooding, these settlements and critical infrastructure will be at severe risk (Lewsey, Cid, & Kruse, 2004; Pernetta, 1992).

External factors such as the track, intensity and duration of storms, the timing and magnitude of river flows, inshore and offshore currents and abrupt changes in sea level, can induce non-linear and complex changes away from the existing equilibrium state in a given dynamic coastal system (Scavia et al., 2002). For example, accelerated rising sea levels where the morphology cannot keep up, can result in changes in littoral drift along the coast and lead to significant erosion, beach movement, submersion of land, increased coastal flooding, salinization of freshwater rivers, bays and aquifers and inland migration of barrier islands loss of protective coral reefs and sand beaches (Gornitz, 1991; Munro, 2010; Pernetta, 1992).Changes in the frequency of severe storms and increased rainfall intensity could further aggravate flooding and storm damage as

[27] Most islands rarely exceed 3-4m above mean sea level, particularly Tonga, Tokelau and the Maldives.

[28] Rings of coral reef which enclose a lagoon e.g. Kiribati, The Marshall Islands and Tuvalu.

[29] Evidence of land lost to sea level rise has been recorded in Kiribati and Tuvalu.

well as affect the timing and delivery of water and sediment to wetlands (Scavia et al., 2002). Changing storm tracks could lead to SIDS closer to the equator – such as Tokelau, Tuvalu, Aruba, Barbados and Trinidad & Tobago – to experience more storms[30] (Kelman & West, 2009). These changes critical thresholds can have irreversible and drastic consequences to the stability and viability of human settlements (Kelman & West, 2009).

As a result of their small land masses and economies, much of their activity and infrastructure which are located in coastal zones can be impacted by higher energy typhoons/hurricanes and storm surges. Increasing economic damages have been attributed to increased development and the appreciation in value of coastal properties (Scavia et al., 2002). Additionally, the degradation of natural coastal systems such as wetlands, beaches and barrier islands removes the natural defenses of coastal communities against extreme surges and high water levels (Nicholls et al., 2007). With the increasing incidence of hurricanes, insurance and reinsurance companies can to withdraw from the market entirely. Those who remain may offer restricted coverages, high deductibles, separate and increased rates for windstorms (Dulal, Shah, & Ahmad, 2009). In some countries, particularly low islands and microatolls, significant portions of land could be lost and resettlement outside the national boundary may the only alternative. Implementing this could become extremely complicated, however, especially for densely populated coastal lowlands and where available and developable land is scarce. In extreme circumstances, some atolls may be abandoned altogether, which could be socially and culturally disruptive. The resulting mass migrations can also affect inland resettlement areas and other receiving regions/territories (Gerrard & Wannier, 2013; Tompkins, 2005).

[30] The impact of these events could be much greater than on SIDS which have more experience with cyclonic activity.

Livelihood impacts

SIDS derive much of their economic, environmental and social well-being directly or indirectly from the symbiotic relationship with rich natural resources in their immediate environment (Barnett & Campbell, 2010; Kelman & West, 2009; Pelling & Uitto, 2001). Climate change is expected to have impacts on several natural resource dependent sectors including the mainstays of farming, non-timber forest product harvesting and processing, fishing and tourism and can have serious implications for macroeconomic stability, employment and sustainability of income generating livelihoods.

Marine ecosystems such as coral reefs are important for the viability of fishing livelihoods as they provide habitats and forage sites for a variety of fish species[31]. The unfavorable effects of higher carbon dioxide concentrations on these ecosystems, coupled with ongoing widespread coral bleaching, pose serious threats to the resilience and livelihood in many small island states. Coral reefs which provide a wide variety of economic and ecological functions including storm protection, biodiversity and fisheries, are particularly threatened by climate change and extremes. Acidification, increased temperatures and an increased intensity or incidence of storms could result in damage and bleaching of coral[32] (Mimura et al., 2007; Nicholls et al., 2007). Global climate models imply that thermal thresholds will be exceeded more frequently, leading to more

[31] Other critical habitats include mangroves, seagrass beds and coastal and estuarine wetlands.

[32] Coral bleaching occurs due to loss of symbiotic algae and/or their pigments. Coral bleach white in response to anomalously high sea surface temperature (1 degree Celsius above average seasonal maxima, often combined with high solar radiation). When environmental conditions return to normal, some corals can recover their color however their growth rate and reproductive ability are significantly reduce. Prolonged bleaching or SST exceeding 2 degrees Celsius above average seasonal maxima, lead to coral death.

bleaching beyond what the reefs can sustain. The synergistic effects of other human factors, particularly overfishing, also exacerbate the stress on reef system (Mumby, Hastings, & Edwards, 2007; Nicholls et al., 2007). Future changes in ocean chemistry due to higher carbon dioxide can lead to weakening of coral skeletons and reduce the accretion of reefs. The frequency and intensity of hurricanes in some regions may lead to shorter time for recovery between occurrences. This process can eliminate more than 90% of corals on a reef, destroy the ecosystem, eliminate tourism and fishing livelihoods and leave the islands exposed to waves and storms (Julca & Paddison, 2010; Kelman & West, 2009). Bleaching events have already impacted reefs in the Caribbean[33] and Pacific[34] and their more frequent occurrence is predicted to reduce coral cover and diversity on reefs (Carmargo et al., 2009; Nicholls et al., 2007). However recent research indicate that coral colonies may exhibit adaptive resilience through acclimatization to new temperatures through the expulsion of one type of symbiotic algae and recovering with more resilient types, creating 'new' ecospecies with higher temperature tolerances. This adaption may increase the temperature threshold at which bleaching would occur. Rather than disappear entirely, these global reefs are predicted to undergo major changes in response to climate change and there is uncertainty whether the present economic and social capacity of coral reefs can be maintained (Hughes et al., 2003).

Fish species constitute a significant source of protein for coastal populations (McClanahan, Allison, & Cinner, 2015; Sumaila, Dyck, & Cheung, 2013). Although the specific effects of climate change on particular marine and inland capture fish populations are difficult to predict

[33] Related to recent disease outbreaks, variations in herbivory and hurricanes.

[34] Related to recent El Nino events as well as non-climate stresses.

and quantify, the general outlook is that availability and distribution of organisms can be affected by changes in water temperature , salinity, precipitation, extreme events and sea level which in turn will affect the migration, recruitment, abundance, composition, production and predatory-prey processes and relationships[35] (Brander, 2010; McIlgorm et al., 2010; Scavia et al., 2002). The fish populations most at risk are those already near their physiological limits in terms of temperature, salinity and pH are severely compromised in terms of their resilience due to existing anthropogenic factors such as overfishing and are in locations most likely to suffer climate change impacts[36] (Barange & Perry, 2009; Grafton, 2010). These impacts can directly affect the size, composition and season of the stock of fish species as well as associated revenues. Changes in species distribution, composition and habitats as well as direct impacts from beach erosion, sea level rise and extreme weather events also affect the location of fishing, farming and processing facilities and transport infrastructure (Mahon, 2002). Reduced livelihood options for fisherfolk may force occupational changes and increased social and economic pressures on vulnerable households which can constrain their ability to effectively anticipate the risks and adapt (Daw, Adger, Brown, & Badjeck, 2009).

Small-holder and subsistence agriculture are vital to the local economies, nutritional status and social well-being of SIDS populations. Farms in rural areas typically tend to be small and often held under traditional and informal tenure in marginal environments (Morton, 2007). With climate change, the growth of subsistence root crops and vegetables is likely to be affected by heat stress, by changes in soil moisture and evapo-transpiration, increased incidence of pests and

[35] Increased risks of species invasions and spread of vector-borne diseases present additional concerns.

[36] Water stress and competition for water resources can affect acquaculture operations.

diseases and by changes in extreme weather events, such as tropical cyclones, floods and droughts (Dulal et al., 2009). Moreover, sea-level rise and its consequent saline intrusion will reduce available cultivable lands and have major impacts on crop production, especially in low islands and atolls where all the crop agriculture is found on or near the coast. These changes can exacerbate existing pressures on traditional agricultural livelihoods, cash-crop exports and broader community scale food security which are already threatened because of growing land degradation, unsustainable farming practices and other non-climate related stressors[37] (Shah, Dulal, Johnson, & Baptiste, 2013).

Tourism is an especially important sector for generating foreign revenues, economic development and employment in SIDS, whose natural beauty and abundance of beaches make these areas prime destinations, but also highly vulnerable to environmental impacts (Scheyvens & Momsen, 2008). Small islands have few economic alternatives to tourism due to limited natural resources and inadequate infrastructure and lack of investment capital (Belle & Bramwell, 2005). Climate is a significant driver of the environmental resources and conditions that provide spaces for tourism activities and plays a major role in the length and quality of the seasons as well as destination choice and tourist spending (Gossling, Hall, & Scott, 2010). SIDS have been identified as the most at-risk tourism destinations for the mid to late 21st century (Mycoo, 2014) The physical and ecological spaces and livelihoods attached to mainstream and niche coastal tourism are at risk to the effects of rising sea levels, warming oceans temperatures and acidification, beach erosion and more frequent and severe storms and storm surges . As such climate change can have differential and far reaching effects on the spatial distribution of

[37] E.g. Land fragmentation and market failures.

preferred tourism destinations and their dependent economies[38] (Berrittella, Bigano, Roson, & Tol, 2006; Klint et al., 2012; Payet & Agricole, 2006; Scott, Simpson, & Sim, 2012; Uyarra et al., 2005). Along with shifting consumer demands to avoid destinations which are negatively impacted by climate change, there is also a concern that with the implementation of mitigation policies in the transportation and aviation sectors, there will be reduced incentives for tourists to travel over longer distances (Cashman, Cumberbatch, & Moore, 2012; Pentelow & Scott, 2010). Outcomes such as these can have serious implications for property values, revenue generation, operating costs, insurance costs as well as short-term and long-term investment strategies in the tourism industry, which in some SIDS comprise as much as 50% of the national GDP.

The intrinsic characteristics of a country influence how resilient it is to hazards. Such inherent characteristics are normally difficult to change and are an important consideration in the overall vulnerability equation (Kaly et al., 2002). The particular vulnerabilities of SIDS will result in ecological, socio-economic and physical impacts that are particular to SIDS, and may not be experienced elsewhere. The potential for loss from a natural disaster in small island states cannot compete in size with those of continental countries, however the relative and proportional impact of disasters will be greater given the potential for high losses of assets and limited resources to cope and recover (J. Lewis, 1990). The increase in the frequency and severity of climate change induced hazards can further hamper SIDS ability to recover between events as well (UNDESA, 2010). Actions taken by SIDS to address environmental governance and management in commons to promote greater resilience and economic and social development has been

[38] For example, Uyarra et al (2005) examined the importance of environmental attributes for the selection of tourist destinations of two Caribbean islands – Bonaire and Barbados. Bonaire focused on marine biodiversity and diving activities, while Barbados featured beach going activities. The study suggested that climate change would have a significant negative effect on tourism in both islands. In the first case through coral bleaching and reduced marine biodiversity as a result of higher sea temperatures; in the second case through reduced beach area as a result of sea level rise.

promising, however there are substantial gaps in providing firm evidence of successes (Roberts, 2010).

In their review of natural hazard impacts Meheux et al., 2007 assert that there is a shortage of detailed studies focusing specifically on the impacts of natural hazards within these nations, in spite of the acknowledged vulnerabilities. The majority of impact research studies appear to be conducted in non-SIDS reflecting a wider bias in disaster literature towards developed countries, and subsequent underdevelopment of disaster studies in developing countries (Khondker 2002). They assert that the unique physical and social characteristics of SIDS support the argument for more SIDS-specific studies. Failure to conduct SIDS-specific studies may result in unique impacts being overlooked and the imposition of inappropriate (non-SIDS) models of impact. The intricacies and unique characteristics of SIDS need to be considered in impact research, but also in the investigation of traditional coping strategies and adjustment to changing impacts and environments.

Chapter 4 . Research Context: The Caribbean Region

Regional Geography

The core and fringe Caribbean Region is located between 11 and 18 degrees north, consisting of 28 insular and coastal states and 10 territories[39] that occupy an area of 5,326,000 million km^2 [40] bordering the Caribbean Sea, the Gulf of Mexico and adjacent areas of the Atlantic Ocean (Ahmad, 2007; UNEP, 2008). The regional climate is characterized by dry seasons from January to June and wet season from July to December. Geological features and landforms range from low-lying carbonate platforms to submerged volcanic mountains (Cropper, 2008). Active volcanoes exist on the islands of Montserrat, Dominica, St. Lucia, St. Vincent & the Grenadines and off the coast of Grenada. Coastal environments consist of diverse and highly productive habitats including coral sand beaches, coral reefs, mangroves, wetlands, rugged coastlines and protected harbors (Boswell, 2009).

The Caribbean region is inhabited by an estimated 40 million people and its physical and cultural attributes position the region as a renowned tourism destination. Fueled by European and North American tourism marketing media streams, the external perception of the region portrays uniformly pristine landscapes of sun and beaches bordered by resorts and natural beauty (Bryan, 2007), rich habitats for endangered species and coral reefs (Baver & Lynch, 2006). The islands of the Greater and Lesser Antilles are linguistically and cultural diverse and their governments

[39] Roughly divided into 5 sub-regions: Greater Antilles - Cuba, Hispaniola, Jamaica and Puerto Rico; Lesser Antilles – smaller islands extending from the Virgin Islands southward to Trinidad & Tobago; The Bahamas and Turks and Caicos Islands; Cayman Islands; ABC Islands.

[40] Guyana (South America), Suriname (South America), Belize (Central America) and Haiti account for 92.79% of the land mass in the region.

differ in form and capacity, but also share a history of colonization, demographic transformation through labor migration, and economic dependence on activities – plantation agriculture, mining and tourism - which dramatically transformed landscapes[41] (Baver & Lynch, 2006).

Figure 2. Map of the Caribbean Region[42].

The most important economic activity in the region is tourism which contributes 30-50% of regional GDP (Ahmad, 2007; UNEP, 2008). Between 2005 and 2009, annual tourist arrivals to the region ranged between 6.7 million and 7.1 million, peaking at 7.45 million in 2007 with

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[41] Caribbean research often separates English speaking Caribbean countries from their Hispanic, French and Dutch neighbors, however this paper will not emphasize the obvious differences in historical, geopolitical and socio-cultural contexts.

[42] Note: From "Caribbean general map" by Kmusser - Own work, all data from Vector Map. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Caribbean_general_map.png#/media/File:Caribbean_general_map.png

Jamaica and Bahamas as the primary destinations (CARICOM, 2013). Tourism is an important source of livelihoods, tax revenues and foreign exchange and is also the only sector of regional GDP that has consistently increased its share of total income during the past 25 years, reflecting the success of the industry and decline of other traditional export activities such as sugar and banana cultivation (Clayton, 2009). Mining and mineral extraction industries[43], are also important engines for economic growth and development in countries such as Suriname, Guyana, Jamaica and Trinidad & Tobago. Fishing provides a vital resource for poor communities as well as significant provider of jobs and income. UNEP (2008) estimates that more than 200,000 people are directly employed as fishers in the region, and approximately 100,000 work in processing and marketing of fish[44], with additional job opportunities in net making, boat building and other supporting industries. Offshore banking has been one of the more successful economic mechanisms in the Caribbean. Some nations provide advantages such as reduction or elimination of taxes on income, profits, dividends and capital gains in secret accounts (Carmichael, 2007).

Regional impacts and trends

The Circum-Caribbean region is one of the most natural hazard-prone regions in the world because of a combination of multiple geophysical, geological and hydrological conditions[45] that characterize the Caribbean region (Ahmad, 2007). As a result increasing population growth rates, greater coastal urbanization and population densities are occurring throughout the region,

[43] Example: bauxite, aluminum, sand & gravel, crude oil, limestone, precious metals and stones.

[44] Example: KingFish, flying fish, red snapper, grouper, shark, shrimp, crab, lobster, conch.

[45] These include shallow, intermediate and deep focus earthquakes, volcanism, geological history and rock types, active tectonics and geological faults, mountainous terrain, volcanic soils and long duration and high intensity rainfall associated with hurricanes and tropical storms.

resulting in concentrations of settlements, hotels and resorts and critical infrastructure in the coastal zones of many Caribbean countries[46], particularly with the movements from the agricultural to coastal tourism sectors. The combined effect of geography, geology and climate together with human dependence on the use of natural assets and human impacts on the environment increase exposure to hazards (Cropper, 2008).

The history of the Caribbean is filled with several examples of climate related catastrophes which have shaped the societies that endured these events and there is evidence that the incidence of disasters is increasing in number, cost and impact (WorldBank-CGCED, 2002; Zapata & Madrigal, 2010). The Atlantic hurricane season of 2004 was one and the busiest and most destructive on record with direct losses and property damage estimated at $5 billion (Collymore, 2005b; Kirton, 2013). The 2005 floods in Guyana affected 40% of the population, causing severe social and economic losses estimated to be around 60% of the GDP including $55 million in damage to the agricultural sector and outbreaks of Leptospirosis (Collymore, 2005a; Dechet et al., 2012) . The 2009-2010 drought caused significant water shortages across the region which induced the implementation of water restrictions in some islands and threatened sectors such as agriculture and tourism and the livelihoods dependent on them (Farrell, Trotman, & Cox, 2010). Hurricanes Nicole and Tomas in 2010 and Hurricane Issac in 2012 caused significant damage and extensive flooding in several Caribbean islands (Berg, 2013). Some Caribbean countries have been identified as particularly vulnerable to extreme events (Crowards, 2000; D. Guha-Sapir, Below, & Hoyois, 2015). For example, Pelling and Uttio (2001) identified

[46] More than 40% of the population lives within two kilometers of the coast.

the Greater Antillean islands of Cuba, Haiti and Jamaica[47] as the most disaster prone island group after reviewing the natural disaster impact and losses of 38 island states from 1900 to 1987 and 1987 to 1997. Rasmussen's (2004) analysis of disasters in Eastern Caribbean States indicated that a disaster occurred at least every 4.5 years, affected approximately 9% of the population and caused damage at 14% of the Gross Domestic Product.

YEAR	DISASTER TYPE	COUNTRY	DEATHS	TOTAL AFFECTED	TOTAL DAMAGE ('000$)
2010	Earthquake	Haiti	222570	3700000	8000000
2008	Storm	Cuba	7	499464	3572000
2004	Storm	Cayman Islands	2	0	3435080
2005	Storm	Cuba	20	2600000	2100000
1998	Storm	Cuba	6	147000	2000000
1998	Storm	Dominican Rep	347	975595	1981500
1998	Storm	Puerto Rico	0	0	1750000
2004	Storm	Bahamas	12	9000	1550000
2004	Storm	Cuba	4	247250	1200000
1993	Storm	Cuba	5	149775	1000000

Table 1. Top 10 costliest disasters in Caribbean 1990-2015[48].

Natural disasters are considered a major reason for the volatility of the GDP of Caribbean economies, short-term derailment of these economies[49] and longer term consequences such as

[47] Data is most complete from the places that have the most data, attention and capacity to report. This may bias the conclusion based on where reporting is sourced and how reporting is conducted.

[48] *Note*: From D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: The CRED/OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

slower growth, higher indebtedness and higher income inequality[50] (Charveriat, 2000; Collymore, 2008; Rasmussen, 2004). The ability of Caribbean states to adequately respond is often constrained by their small economies, limited technological resources and low adaptive capacities (Raid, Arthur, & Dexter, 2011).

The interconnectedness of economic growth and ecosystem health mean that uncertainty about climate change will have significant consequences for the economy and the environment (Pelling & Uitto, 2001). For the Caribbean Region, the IPCC predicts that air and sea surface temperatures will rise between 1.4 and 3.2 degrees Celsius. Sea level is predicted to rise between 0.18 m to 0.59 m. The predicted rates for regional sea level rise are the same as the global predictions (around 1.8 mm/yr) (IPCC, 2007a). While annual rates for sea level rise of less than 2 mm may sound insignificant, they have a significant effect on beaches and low elevation coastal zones[51] (G. Cambers, 1997; Gillian Cambers, 2009). It is also likely (>66% certainty) that the region will experience an increase in hurricane intensity with larger peak wind speeds and heavier precipitation. The number of flood events are expected to increase, yet the extent of drought is unclear. No clear predictions for the region exist for overall precipitation although

[49] Scarce resources that are earmarked for development projects are often diverted to relief and reconstruction following disasters.

[50] Rasmussen's (2004) macroeconomic assessment of natural disasters revealed an immediate contraction in economic output, worsening of external balances, deteriorating fiscal balances, an increase in poverty and longer term damages to agriculture, fishing and forestry industries when a natural disaster occurred in the Caribbean.

[51] Observations over a 20 year period, 1988-2008, in Nevis reveal that the water line has retreated inland by 18 m (59 feet) at Pinney's Beach. This erosion is due to a combination of sea level rise, the passage of several hurricanes and anthropogenic factors including construction close to beaches, poorly planned sea defense structures, sand mining and offshore dreading. Measurements in six of the smaller islands over the period 1985-2000 showed the beaches retreated inland at an average rate of 0.5 m/yr and that those islands impacted by hurricanes had much higher rates.

some models predict a decrease in precipitation in the summer months in the Greater Antilles (IPCC, 2014). Results of a recent regional climate modeling project for the Caribbean region, which was undertaken jointly by the University of the West Indies and the Institute of Meteorology using the United Kingdom Hadley Centre's PRECIS model, indicate similar changes in average temperatures were that by 2080 an annual warming of between 1° and 5° C would be experienced through the Caribbean, depending on the region and scenario. The warming would be greater in the northwest Caribbean territories of Cuba, Jamaica, Hispaniola, and Belize than in the eastern Caribbean island chain. Also, there would be greater warming in the summer months than in the cooler and traditionally drier earlier months of the year (Cashman, Nurse, & John, 2010).

A changing climate threatens every facet of Caribbean life and places greater strain on limited natural resources and narrowly based economies, and in the most extreme circumstances, render large portions of the islands uninhabitable (Georges, 2003). Throughout the region, several over-arching forces have shaped specific trends in vulnerability, such as increasing population densities and growth rates, the fast expansion of the tourism industry**,** particularly at the expense of agriculture, and uncontrolled coastal development and urbanization. The close link between environmental degradation and poverty, lead many low income communities with limited resources, lack of land ownership to settle in hazardous locations. These trends and others, coupled with inadequate policies and enforcement of those in effect, have at times resulted in the destruction of critical ecological buffers and increased the vulnerability of coastal infrastructure and land uses in the Caribbean (Clarke, Charveriat, Mora-Castro, Collins, & Keipi, 2000).

Regional research and policy responses

Much of the research on climate change in the Caribbean focuses on analyzing the science of climate change, observed trends, future projections and its implications. The improved resolution of Global Change Models to regional and sub-regional scales has provided data necessary to anticipate climatic conditions within the region (CARICOM, 2013). Observational data from the late 1950s to 2000s reveal that the number of very warm days and nights in the Caribbean has increased dramatically, while the very cool days and nights are decreasing and inter-annual temperature ranges are also decreasing. The number of heavy rainfall events is increasing; however there is a trend toward an overall decrease in precipitation and prolonged dry spells. In 2001, scientists from around the Caribbean region analyzed indices of extremes from daily weather observations in the region. The results indicated that the percentage of days with very warm maximum or minimum temperatures strongly increased since the last 1950s, while the proportion of days with very cold temperatures decreased (Peterson et al., 2002). Extreme precipitation also showed an increase over this time period and the consecutive number of dry days is decreasing. Recent results from studies carried out by the Institute of Meteorology in Cuba and the University of the West Indies have indicated that the mean temperatures of individual Caribbean territories have demonstrated an upward trend during the last three decades. The studies also showed that the frequency of droughts has increased significantly, whereas the frequency of other extreme events in the region seems to be changing with flooding events and hurricane passage through the region increasing since the mid-1990s (Taylor, Stephenson, Chen, & Stephenson, 2012).

Models at finer scales have projected the impact of sea level rise in various Caribbean localities. For example, (Mycoo & Sutherland, 2010) began the research by assessing the vulnerability of ecosystems to climate change and the impact on sea turtles at Grande Riviere Beach in Trinidad. The study investigated the potential impact of sea level rise and its implication for beach loss on the survival of the leatherback turtles. Scenarios of 0.4m, 0.5m, 0.6m, 0.8m and 1m rises above mean sea level were created and modeled in GIS using topographic and hydrographic field survey data. Levels of risks to critical facilities and properties in the community were made using spatial GIS models. Mean Sea Level (MSL) at Grande Riviere Beach was visualized using Arc GIS software, with projections of 0.4m, 0.6m and 0.8m. At a simulated 0.4m sea level rise above MSL approximately 2,060 m^2 of the beach may be lost, either to inundation or beach retreat, representing approximately 44% loss of turtle nesting habitat and private property boundaries are also impacted. A simulated 0.6m sea level above MSL, approximately 2,900m^2 (or approximately 60%) of turtle nesting habitat may be lost to inundation or beach retreat, private property boundaries continue to be impacted. At a simulated 0.8m sea level rise above MSL approximately 3,200m^2 (or 68% of turtle nesting habitat) may be lost to inundation or beach retreat. Private property boundaries would continue to be impacted and physical infrastructure in the form of beachfront hotel buildings begins to be physically impacted as well. These models indicate serious physical impacts to the nesting beach at Grande Riviere which could affect turtles nesting habits and choice of nesting sites which in turn could negatively affect the socioeconomic well-being and livelihoods of the community (Michael Sutherland & Seeram, 2011).

Attention is also growing on the economic dimensions of climate change at regional and national scales. (Moore, 2010) forecasted the impact of changes in tourism demand likely to emanate from climate change for 18 Caribbean countries using estimates from four of the most likely climate scenarios. The analysis revealed variations in outcomes base on the scenarios and countries. A1 and A2 scenarios suggested slight improvement in tourism demand due to changes in climatic features, while B1 and B2 scenarios[52] suggested a contraction in the regional tourism industry by about 1.2% per year. This decline translates to an approximate loss of between US $`18 million and US $146 million in tourist expenditure. Some countries such as Dominica, the Dominican Republic, Haiti and Suriname are projected to experience an increase in tourism demand while demand in countries like St. Lucia are expected to decline. An admitted limitation to the study is that it does not consider the potential reductions in tourism demand that could occur should the region experience higher frequency of hurricanes and other natural disasters, declines in biodiversity, damages to hotel infrastructure as well as overall global shits away from or to the region. In 2011, the Economic Commission for Latin America and the Caribbean (ECLAC) undertook a series of econometric and scenario modeling studies to evaluate the economic impact of climate change on critical and vulnerable sectors – Tourism, Energy, Agriculture and Health - in Trinidad & Tobago, Barbados and Jamaica under the business as usual (BAU) climate scenario and two alternative climate scenarios A2[53] and B2[54] (ECLAC, 2011) .

[52] The main factor driving the decline in tourist arrivals was the projected rise in temperature.

[53] Self-reliance and preservation of local identities; continuously increasing population; economic development primarily regionally oriented and per capita economic growth and technological change more fragmented and slower; high emission trajectory with relatively weak global environmental concerns;

Climate change has moved rapidly up the research and policy agendas to become a defining feature of the Caribbean region's development landscape (Pulwarty, Nurse, & Trotz, 2010). Moreover, given its intrinsic trans-boundary nature, it will, over time, come to impact upon the political economy of every territory of the region in broadly similar and possibly dramatic ways. In this sense, it is the ultimate Pan-Caribbean issue (Bishop & Payne, 2012). Since 2000, the regional body CARICOM has implemented a series of projects to help understand the region's vulnerability to climate change, build capacity, develop and implement adaptation plans and mainstream adaptation throughout different sectors. In 2005, the Caribbean Community Climate Change Centre (CCCCC) was established in Belize under the aegis of CARICOM, the main institution of regional governance within the Caribbean encompassing the independent English-speaking Caribbean, Suriname and Haiti. The CCCCC serves as the official repository and clearing house for regional climate change data, providing climate change-related policy advice and guidelines to CARICOM Member States[55] (CCCCC, 2011a). Most Caribbean SIDS have outlined national adaptation needs and measures within their National Communications to the UNFCCC[56]. These documents reflect a strong focus upon the importance of ecosystems for

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[54] Emphasis on local solutions to economic, social and environmental sustainability; Increasing population growth but slower than A2; intermediate levels of economic development; low emission trajectory.

[55] Although there exists technical co-operation, CARICOM does not include in its membership a number of significant Caribbean countries, such as Cuba, the Dominican Republic or the non-independent French or Dutch territories (or indeed Puerto Rico) .

[56] The only Caribbean countries which have moved beyond their initial national communication to the UNFCCC in 2001 by producing a Mauritius5 National Assessment Report (NAR) are those which are, relatively-speaking, among the most successful economically: Barbados, Cuba, Grenada, St. Lucia and T&T.

climate change adaptation but do not specifically discuss the need to integrate local perspectives and stakeholders in the climate planning process (Bishop & Payne, 2012)..

Despite this growing salience, a number of gaps exist in both the general and the specifically Caribbean academic literature on the subject (CCCCC, 2011b). The science is not in question. Rather, the social science of climate change has been sparse, with the consequence that practical attention to the amelioration of problems has been, at best, piecemeal and the impact on local human-ecological systems as well as the local institutional ability to anticipate and adapt to changing climatic conditions remains underexplored. The major problem is that, regionally, there is very little understanding of how the likely impacts of climate change should translate into adaptive policy-making. Some of the socio-economic studies previously mentioned provided a general overview of the vulnerability issues facing Caribbean nations collectively as well as adaptive strategies that can be applied. However, understanding the local context is limited by the nature of the regional scale perspective. The nuances of local impacts and vulnerabilities are often masked when conducting regional or national assessments. Assessing national and community scale circumstances is needed to understand the finer grained drivers of vulnerability and better tailor responses which contemplate local conditions cultures and capacities. Although the results are case specific, understanding localized vulnerabilities can serve to develop targeted strategies that contemplate the specific conditions and needs of the area under study.

Chapter 5 . Research Questions

Natural disasters are on the rise, in spite of tremendous advances in technology, well known probabilities, prediction and preparedness. Societies remain ill-prepared to cope with extreme events and their potentially undermining impacts on development, poverty reduction and environmental protection (Thomalla et al., 2006). The impact of hazards on SIDS, demonstrates a disproportionate impact not usually experienced by continental countries in terms of area or population affected, housing and infrastructure damage and economic loss (Kaly et al., 2002). In some instances, the survival of whole islands is at risk in the face of climate and hydro-meteorological disasters which can devastate entire agricultural sections, settlements and inflict a high proportion of damage on inhabitants and critical infrastructure. Relatively small shifts in settlement location from the coastal plan to more elevated ground can impact the level of exposure. However, efforts to reduce risk can backfire when livelihoods and social networks are disrupted or when humanitarian relief is ineffective (Schipper & Pelling, 2006). Questions of equity also arise when instituting restrictive coastal settlement policies which can undermine the lives and livelihoods of the most vulnerable residents dependent on the environmental services provided by coastal ecosystems (McGranahan et al., 2007). This study aims to understand the nature of localized experiences with extreme weather events and what, if any, opportunities exist to build local resilience to weather extreme events in a vulnerable coastal region where resources are constrained.

The relationship between climate change adaptation and disaster risk reduction is straightforward. Planning for climate change is fundamentally a risk management strategy against uncertainty of the future (Russell & Griggs, 2012). Successful mitigation of climate change can decrease disaster risk by reducing weather related uncertainty and the occurrence of hazards and reducing the threats among vulnerable societies while building the asset base available to cope with disasters (Schipper & Pelling, 2006). Thus, disaster risk management has been considered an adaptation option and as a pathway to sustainable development. As a result, focusing on disaster response and prompt rebuilding after a disaster[57] has transitioned to new approaches to disaster reduction and long-term sustainability which couples stronger imperatives for mitigation, reflexive action and proactive planning that contribute to lasting improvements in human safety, economic stability and resilient environments (Ahmad, 2007; Rose, 2011).

In-spite of the natural overlap, disaster scholars and practitioners hardly engaged in climate change debates until recently (Helmer & Hilhorst, 2006; J. K. Mitchell & van Aalst, 2008; T. Mitchell, van Aalst, & Villanueva, 2010; O'Brien et al., 2006; Venton & La Trobe, 2008). Since the Caribbean is categorized as one of the most vulnerable regions to climate change and there is limited data on the finer grained impacts of and local level responses to certain climate-related hazards in the Caribbean (CDEMA, 2010; Collymore, 2008; Meheux et al., 2007; Mahabir, 2007; Mimura et al., 2007), the study seeks to attend to and bridge this disciplinary gap in the literature and practice.

The questions guiding this research study are as follows:

1. What is the socio-spatial nature of risk to extreme events in the Turtle Region of Trinidad?
2. How have households responded to extreme events in the Turtle Region of Trinidad?

[57] E.g. Galveston Flood of 1900, the Long Beach Earthquake of 1933 and Hurricane Andrew in 1992.

The study relies primarily on the Disaster Resilience of Place Model advanced by (Cutter et al., 2008) as the analytical framework to explore these questions.

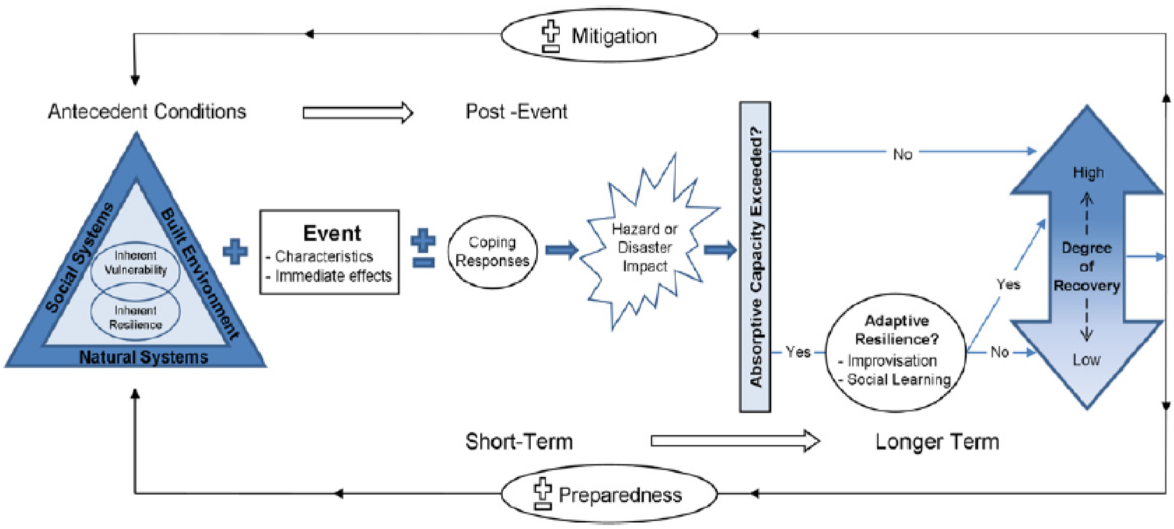

Figure 3. Disaster Resilience of Place Model[58]

In the DROP model the total hazard or disaster impact is a cumulative effect (or sum) of the antecedent conditions, event characteristics, and coping responses. The overall local impact can be moderated by the absorptive capacity of the community. If a community implements sufficient coping responses, the impact of the hazard event will be attenuated and the absorptive capacity of the community will not be exceeded, leading to a high degree of recovery. If absorptive capacity is exceeded the community may exercise its adaptive resilience through improvisation and learning. Improvisation includes impromptu actions which may aid in the recovery process. Manifestations of social learning include policy making and pre-event

[58] *Note*. From Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*, 598-606. Copyright 2008. Reprinted with persmission.

preparedness improvements. When improvisation and social learning take place, they directly alter the inherent resilience for the next event.

(N. W. Adger, Arnell, & Tompkins, 2005) and (McGranahan et al., 2007) broadly group the possible options for national governments of SIDS to deal with flooding and inundation as retreat, accommodation and protection. With retreat, development is prevented near low-lying coastal areas through coastal set-backs, zoning, subsidies for coastal development are withdrawn and infrastructure development is confined to higher ground[59]. Accommodations include structural improvements or adjustments to housing and building construction standards or design to make them more resistant to hazards. Critical infrastructure and storage facilities can be moved or given flood protection. Adjustments to land use pattern and practices along with using drought or salt resistant crops could be substituted in lieu of traditional or current varieties can increase resilience within agricultural systems. Investments in water storage, irrigation systems or use of more efficient water management can buffer against water shortages or erratic supplies. Improvements in public health measures and stricter quarantine measures could protect against the spread of dengue fever, malaria and other health risks which can arise in the wake of tropical storms (Munro, 2010). Protection strategies involve the construction of hard structures such as sea walls and barriers[60]. These would prevent future sea surges, but may not entirely prevent inland flooding or damage from high intensity winds. Sea defense construction would only be feasible if reformations of the land were cost effective, structurally practicable and technically

[59] Retreat is feasible only in areas when land is plentiful and there is little coastal development; The most extreme form of retreat is mass evacuation and island abandonment.

[60] For more affluent urban island settlements, these are feasible and cost effective options but can also increase coastal erosion elsewhere.

possible (Lewis, 1990). Ecosystem-based measures such as coral reefs, sea grass and mangroves protect the coastline and provide natural buffers to storm surges and offer preferable low cost options which generate several socio-ecological co-benefits (Randolph, 2004).

Adaptive capacity refers to a learning phase that a system undergoes after a perturbation. In the context of climate change literature, adaptation refers to the long-term process of adjustment that takes place in natural or human systems in response to the actual or expected impacts of climate stimuli and aims at moderating harmful impacts and exploiting beneficial opportunities (Klein, 1999; Klein, 2003). The concept acknowledges that vulnerable communities, sectors and countries may have differential access to mechanisms, technologies, expertise and other resources to recover from past impacts and reduce vulnerability to future events. However, they all need to learn to cope over time with known and unknown changes in climate (W. N. Adger, 2003).

Adaptation responses differ from coping responses as more attention is directed to loss reduction where proactive action is taken to reduce loss and/or radical change where loss is no longer tolerable and active change is pursued. The basic coping strategies in the context of environmental risks to livelihoods can be classified into five analytical categories of adaptation responses and their combinations: mobility/migration, which helps address risks across space, storage (time), diversification (asset classes), communal pooling (across households), and market exchange – which can substitute for the above four classes of risk mitigation when households and communities have access to markets. As these strategies are implemented, the capacity of households to deal with present and future events increases. This analysis uses these categories of adaptive responses and a brief review of each is adapted from (Agrawal, 2008) :

Migration is the most common and seemingly natural response to environmental shocks. It pools risks across space, and is especially successful in combination with clear information about the spatial and temporal distribution of a particular hazard. In the context of climate change mobility has sometimes been viewed as a mal-adaptation, in which climatic stresses lead to involuntary migrations on a massive scale with attendant social and political instabilities. However, mobility is also a way of life for large groups of people in semi-arid regions, and a long standing mechanism to deal with spatial-temporal variations in rainfall and range productivity. Different patterns of migration can occur as a result of different events – migration within the region, outside of the area but within the same country or internationally. These migrations are not necessarily permanent but rather necessary and temporary movements away from the site of impact until conditions stabilize. Restricting the ability of groups to move away from a place which has been decimated by an event can further increase suffering, vulnerability and reduce the groups' ability to recover. Migration as an adaptation practice, therefore, is more or less desirable depending on the social groups being considered. For coastal populations and economies facing encroachment of the sea, mobility can often be the last resort in the face of environmental risks and disruption of livelihoods.

Storage pools and reduces risks across time. When combined with well-constructed infrastructure, low levels of perishable items, and high levels of coordination across households and social groups, it is an effective measure against even complete livelihood failures at a given point in time. As an adaptation practice to address risks, storage is relevant to individual farmers and communities, and addresses food as well as water scarcities. In light of the significant losses of food and other perishable commodities, improvements in storage technologies and institutions have immense potential to improve rural livelihoods.

Diversification pools risks across assets and resources of households and collectives. Highly varied in form, it can occur in relation to productive and nonproductive assets, consumption strategies, and employment opportunities. It is reliable to the extent benefit flows from assets are subject to uncorrelated risks. Diversifying households typically give up some returns in exchange for the greater security provided by diversification.

Communal pooling refers to adaptation responses involving joint ownership of assets and resources; sharing of wealth, labor, or incomes from particular activities across households, or mobilization and use of resources that are held collectively during times of scarcity. It pools risks across households. It is most effective when the benefits from assets owned by different households and livelihoods benefit streams are uncorrelated. When a group is affected in a similar manner by adverse climate hazards – eg, floods or drought, communal pooling is less likely to be an effective response. Joint action on the one hand increases the range of impacts felt by a community in comparison to what households could have coped with individually. It also requires functioning and viable institutions for coordination of activities across households. It is one way for social groups, especially those dependent on natural resources for livelihoods, to enhance their capacity to adapt to the impacts of future climate change as advocated by (Tompkins & Adger, 2004).

Market Exchange is perhaps the most versatile of adaptation responses. Markets and exchanges are a characteristic of almost all human groups, and are a mechanism not just for adaptation to environmental risks but also critical for specialization, trade, and welfare gains that result from specialization and trade at multiple scales. Market exchange-based adaptation practices can substitute for the first four strategies when rural poor have access to markets. But they are likely to do so mainly when there are well developed institutions to facilitate market access. Further, equity in adaptation practices based on market exchanges typically requires great attention to the institutional means through which access to markets and market products becomes available to households. In the absence of institutional mechanisms that can ensure equity, the rural poor are less likely to benefit from purely market exchange based adaptation. Particularly in the event of a major disaster event markets can be distorted and exploited by high prices for scarce resources and the development of illegal markets to gain access to these resources.

The choice of specific adaptation practices is dependent on social and economic endowments of households and communities, and their ecological location, networks of social and institutional relationships, institutional articulation and access, and access to resources and power[61] (N. W. Adger et al., 2005). Although rural households may be poor, access to natural resources and social networks are more readily available compared with urban populations, which can mean that they can buffer against shocks in rural areas in-spite of the availability of humanitarian aid in urban areas. In terms of being more capable of surviving in difficult conditions, rural populations may be better equipped to cope and adjust.

[61] For example, the poor are more likely to migrate in response to crop failure; the rich more likely to rely on storage and exchange.

Disasters can quickly erode income generating sources and flows over the short and long terms. Whether households and communities can diversify into new occupations and assets depends on the extent to which they have the ability to trade some level of returns for lowered risks, but it also on access to capital, availability of skills training, and the effectiveness of livelihood extension institutions. Thus, institutions play an important role as the scaffolding on which households and individuals can coordinate their expectations and thereby create effective collective action.

Several assumptions are implicit in this analysis. First, the analysis focuses on address climate related extreme events, but can also be extended to apply to slow onset climate hazards like drought and sea level rise. The analysis focuses on impacts, responses and adjustments at the household scale and how these translate to resilience at the community level, thus distinguishing it from models created to assess vulnerability or resilience at the meso- or macro-level or models based on sectors. The main focus of this analysis is on the social resilience of communities and households; however, other forms of resilience exist and cannot be separated from social processes. Human actions impact the state of the environment and, in turn, a degraded environment provides less protection against hazards. Thus, the analysis regards resilience as both an outcome and a driving condition / process. These components can be viewed as a snapshot in time or as a static state, yet the pre and post-impact processes embedded within the model allow the conceptualization to also be dynamic. Finally, while the study attends to local circumstances, it is recognized that exogenous factors such as technology, national policies and politics do exert powerful influences on resilience at the community level.

Chapter 6 . Methodology

A mixed methods approach was employed to increase the validity and the reliability of the data by capitalizing on the strengths of each data collection method. The research questions directed three phases of data collection and analysis. The first phase consisted of a qualitative hazard impact assessment which examined the spatial distribution of impacts of extreme events using secondary data, site observations and focus groups with members of community-based organizations. The second phase examined the nature of impact and responses of households in different communities which are exposed to hazards such as coastal erosion and flooding events. This portion of the data collection consisted of a household survey conducted in three Turtle villages. The final phase explored the institutional challenges and opportunities to build resilience to extreme events through interviews with national and local government officials as well as community leaders. The following sections details each phase of the study design and associated methodological concerns.

Phase 1: What is the nature of the spatial impacts of extreme events in the Turtle Region?

This phase of the study is focused on the physical exposures and the losses which have occurred in the region as a result of extreme events. Hazard event identification and assessment tools are critical for capturing data on complex physical processes in order to support policy decisions and management outcomes. The situation in which risks are assessed is dependent on the hazard in question. Risk assessment involves four basic elements: hazard, inventory[62], vulnerability and loss[63] and involves three steps as outlined by Randolph (2004):

[62] Description of property, humans and physical environment at risk; Includes evaluation of location, physical dimensions and construction quality.

1. Hazard identification: which provides descriptions of the history, intensity[64] and location and inventory of the number and type of structures and infrastructure, their value, use and construction

2. Hazard exposure and vulnerability assessment: which combines the information from hazard identification with an inventory of existing property and population exposed to a hazard and predicts how a hazard will affect different properties and population groups and estimate probability of occurrence and extent of damage.

3. Risk analysis/characterization: which estimates the communitywide or site-specific damage, injuries and costs likely to be experienced overall period of time. Risk analysis involves combining assessment of relative hazard, exposure and vulnerability as well as analyzing the probability of occurrence of hazard events of varying magnitudes impacting specific areas and relies on historical, inventory and scientific data.

Secondary Data Collection and Document Reviews

The main sources of secondary data were official records and news reports of past events, document reviews of prior risk assessments performed in the region and site observations of impacted areas. Demographic and socio-economic data from the 2010 census was sourced from

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[63] Can be direct – injuries, fatalities, financial losses, cost to repair or replace a structure, restore a services etc; or indirect – future forgone income, slow growth, longer term consequences of evacuation, disrupted services etc.

[64] E.g. For flooding – area flooded, water depth, water velocity; for hurricanes – wind velocity.

the Trinidad & Tobago Central Statistical Office; average monthly rainfall and temperature data for the past 30 years was sourced from the Caribbean Meteorological Organization; vulnerability assessment data was sourced from the Office of Disaster Preparedness and Management; A regional carrying capacity study conducted by PLANVIRON Associates was also sourced. These descriptive data were used to develop a background narrative on the past and present risks faced and critical exposures in the Region.

Site Observations and Visual Data Collection

The assessment consisted of qualitative observations to identify present-day physical exposures, evidence and severity of impacts and the presence of remedial measures. The general categories and prompts for observational analysis are listed in Appendix D.

The observations along the main coastal road which connects all the villages in the region, beginning at the village of Matura and ending at the village of Matelot. The researcher was accompanied by a community leader familiar with the area, sites of impact and at-risk areas. The team traveled and visited sites where landslides occurred, obvious coastal erosion and subsidence / inundation is occurring and where flooding events occurred. The extent of the observations was limited to the areas accessible by car or by walking on the beach zones, roadway and neighboring foothills. These zones are the primary locations where the hazards occur, although activities beyond these zones can influence the actualization of a hazard impact. Areas of impact were assigned ratings on scale of 1-5 based on the present-day physical exposures, evidence and severity of impacts and the presence of remedial measures. The total of ratings provided data that could be mapped to identify areas of impact using Google Earth.

Photographs were taken to document the physical environment including critical ecological habitats, community infrastructure, risk mitigation structures as well as at risk populations, cultural assets and social spaces. These visuals were used to create an enriched understanding of place and context, by capturing macro-scale / panoramic views as well as more micro-scale / key issue photographs from the field (Razvi, 2006). The visual data was incorporated into the risk profile map using a GPS locator and tagging the impact sites to equivalent coordinates on the assessment map. The site assessment was supplemented with field notes and analyzed alongside data from the focus group workshops and household survey to categorize and search for patterns. Careful consideration was taken to ensure informed consent was attained for all images.

Focus Groups

Focus groups can reveal a wealth of detailed information and insight when administered in a supportive environment. Two focus groups of members[65] belonging to focal community-based organizations were convened in each community to develop through discussion exercises a ranking of the major hazards and events that have impacted the region.

Women are often identified as having high vulnerability to environmental hazards, experience and are often the most active community members in informal and formal community organizations although men tend to lead these organizations (Pelling & Uitto, 2001). Assigning the women and men into separate focus groups attends to concerns about power differentials

[65] Working adults between the ages of 18-60

and create a safe environment where each group can feel comfortable to share their opinions. However after discussing the request with leaders of the organizations, they preferred to conduct the workshops a mixed gender workshops.

The leaders of each community organization nominated participants who were familiar with the community, known for their ability to respectfully share their opinions and willing to volunteer their time. Each workshop was 2 hours in length and followed a protocol defined by the researcher but guided by the participants (See Appendix E). Responses from discussions were recorded on large poster boards to ensure all participants were aware of findings. A short demographic survey was administered at the beginning of the session in order to assess with focus group findings. All participants completed a consent form. The recordings and notes were transcribed, coded and thematically analyzed.

The challenges of participatory data collection such as the difficulty of managing the role of an unbiased, external researcher may have some relevance to this study. As a Trinidadian native, barriers to entry within these communities was less prominent, however, given the small size and remote nature of these communities, members were wary of outsiders. Connections with leaders in local community based organizations facilitated entry and enabled access to information within each community. An effort was made to maintain a neutral position and my presence as a community outsider did not appear to negatively influence the actions of stakeholders or lead to a performative presentation of relationships and activities.

Phase 2: What are the social impacts and responses to weather extreme events?

In their review of natural hazard impacts in island states, Meheux et al., 2007 assert that there is a shortage of detailed studies focusing specifically on the impacts of natural hazards within small island nations, in spite of the acknowledged vulnerabilities. The intricacies and unique characteristics of SIDS need to be considered in impact research, but also in the investigation of traditional coping strategies and adjustment to changing impacts and environments. While the site assessment and document review approaches are intended to determine the spatial component of impact, different research tactics are necessary to develop an understanding of the household impacts and responses to extreme events.

In order to evaluate the nature of impact, responses and recovery strategies, a household survey in three communities were conducted. Surveys can provide researchers with data that can be quantified and analyzed to identify trends, relationships, significant predictor variables and possible outcomes. The survey instrument was developed by the researcher guided by the disaster risk management cycle framework which identifies five stages: Impact/loss, Absorb/Cope, Adjustment/Recovery, Mitigation/Preparedness (Blaikie et al., 2014). With the inclusion of a section to capture demographic and livelihood data of the respondent and household, the survey consisted of 6 main sections and totaled 50 questions (See Appendix G). The survey was a mix of open and closed questions to gather data that could be analyzed statistically, but also enable respondents to provide additional information through free responses.

The villages were purposefully selected due to the presence of established community-based organizations which were able to facilitate the dissemination of the survey. The villages were also selected based on differences between the type of economy and physical location of the village to enable comparisons to be made.

The total sample of respondents was 126, which represents approximately 10% of the population in the three villages selected. A stratified representative sample to represent the size of each community was used.

The survey was administered face-to-face. In order to increase the reliability of the validity of the survey through randomization, a schedule of random numbers were developed in Excel and given to survey administrators. Each house was counted and assigned a number. The household with corresponding number on the random schedule was surveyed. If there was no answer at the household, the house with the next randomized number was selected. Houses which were physically inaccessible were not included in the sample. Each survey was numbered based on the village for coding purposes.

Financial assistance was provided by one of the community-based organizations with the understanding that results and recommendations from this research will be shared. Availability of funding enabled survey administrators to be hired and compensated at a rate $150TT per 6 surveys administered. Survey administrators were selected based on familiarity with the community layout and members. They were trained in an hour long session with the researcher and instructions, questions and response options were explained by the researcher. The survey administrators were responsible for reading and completing the survey. All additional terms and conditions were disclosed by the researcher.

The surveys were administered between July and August. All completed surveys were compiled at the community-based organization office and coded. The hard copies of surveys and codes were then submitted to the researcher. To the greatest extent possible, any errors in coding were checked and corrected. The data were analyzed using SPSS Statistical Software. Given the small sample size and categorical data, most analyses consisted of cross tabulation analysis and statistics.

Interviews

Semi-structured interviews with informed members of key local and national public agencies and non-governmental organizations involved in the region were conducted. Participant recruitment was directed by a purposeful sampling method (See schedule of interview participant agencies in Appendix B).

Valuable information can be gained from interviewing elites who can provide overall views of an organization, its history, policies, plans and relationships to other organizations (Marshall & Rossman, 2006). The interviews of professionals and practitioners was structured to capture two broader perspectives of the social impacts and responses to extreme weather events including their agency's / organization's role in promoting resilience within the region. Interviews conducted with regional and national program directors and managers attended to broader questions about the conceptualization of resilience, its translation to concrete policy directives and place within the overall strategic vision of national development. Questions directed at local program officers, implementers, consultants and planners focused specifically on the impacts, outcomes and institutional responses to extreme weather events in the region. These questions were posed in semi-structured open-ended format to give respondents the latitude to articulate their opinions and maximize response validity as respondents can organize their answers within their own frameworks. The interviews were tape-recorded in order to facilitate use of conversational style and minimize information loss. The interviews were transcribed and thematically coded for further analysis of common themes and deeper meanings of responses were evaluated.

There were some limitations associated with interviewing political elites and practitioners which were anticipated. First, difficulties arose in trying to secure interviews with busy officials operating under demanding time constraints. Because these individuals continue to reside in separate departments with their own mandates and funding structures, there may have been potential for interviewees to present biased perspectives on integration and/or exaggerate their role or level of influence in the region. Finally, there may have also been a tendency to downplay the role of other actors or omit their participation, because of underlying political agendas or interest of participants to overstate their roles. To address these issues, an introductory letter and follow-up phone call to arrange interviews, emphasizing the importance of the interviewee's participation (rather than an alternative), were made. Those interviewees who remained unresponsive after multiple attempts to arrange interviews were replaced by informed alternative interviewees from the respective agency. Interview questions were designed to be mostly open-ended to allow interviewees to use their knowledge and imagination. Participants were also given the opportunity to review my interpretation of their interviews as well as respond to comments made by other participants.

Chapter 7 . Study Zone

Trinidad is the larger of the two-island state of Trinidad & Tobago. It is located on the continental shelf of South America, off the north coast of Venezuela in the Caribbean Sea between 10^0 N and 11.5^0N latitude and between 60^0W and 62^0W longitude. The island is approximately 4,800 square kilometers with a population of approximately 1.2 million. Three low mountain ranges[66] cross the landscape in an approximately east-west direction with highest elevation at 940m, interspersed by two fertile plains.

The Trinidad economy is based on a relatively significant industrial sector, supported principally by petroleum and petro-chemical extractive and derivative industries[67] even though the sector only employs less than 5% of the population (Artana, Auguste, Moya, Sookram, & Watson, 2007; Braveboy-Wagner, 2010). The tourism industry contributes approximately 3-4% to the country's $24.43 billion annual Gross Domestic Product (GDP) and accounts for over 30,000 jobs or 5% of the labor force (A. Lewis & Jordan, 2008). Less than one percent of the country's GDP is derived from agriculture (CSO, 2013). However, the volatility of energy markets and reality of declining reserves, has promoted the Government to emphasize sectors such as tourism financial services and manufacturing to reduce the country's reliance on the energy sector (GovTT, 2014).

[66] Northern, Central and Southern Ranges.

[67] 34-41% of GDP from 2009 -2013.

The island experiences two relatively distinct seasonal climates - typical tropical marine climate[68] and modified moist equatorial[69] - with main seasonal variations of rainfall between the wet season (June to December) and dry season (January to May) (Mahabir and Nurse, 2007). Mean temperature is approximately 26 degrees Celsius with average minimums ranging between 20-23 degrees Celsius and average maximums range between 30-31 degrees Celsius depending on the season (GovTT, 2011). Recent data analysis indicates an increase of 1.7 degrees Celsius over the period 1961-2008, implying an increased rate of warming (GovTT, 2011). Rainfall varies between 200-250 mm per month in the wet season and also varies by topography. There has been no statistically significant change in mean rainfall over Trinidad & Tobago since 1960. However, a decrease of 6.1mm per month per decade in rainfall during the months of June, July and August have been observed. Additionally, an analysis of rainfall data from the Nariva Swamp for the period of 1951 to 2000 also reveals a decrease in cumulative rainfall (GovTT, 2011).

The coastline of Trinidad is varied and largely comprised of unconsolidated and consolidated sedimentary rocks where the north and east coasts of Trinidad are moderately stable while the south coast of Trinidad is visibly unstable and eroding (Kenny, 2002). Observed sea level rise estimates range between 1.6mm and 3.0mm per year over the period of 1984 – 1992 (M. Sutherland, Dare, & Miller, 2008). In 2010, the Institute of Marine Affairs (IMA) undertook a study to assess coastline change for Trinidad and Tobago, utilizing 1994 aerial photography and 2000-2007 high resolution remote sensing imagery. While most of the changes were categorized as negligible, there are a few areas where the change is significant: the north and

[68] Warm days and cool nights with rainfall in the form of showers due to daytime convection.

[69] Low wind speeds with hot humid days and nights and marked increase in rainfall that is not always convective.

southwest coasts of Trinidad. Along the north coast sea level has been estimated to rise at a rate of 1mm/year while in the south, the rate is about 4mm/year (Mimura et al., 2007).

Flooding is a perennial problem where heavy rains can cause flooding in major river basins and along the foothills of the Northern Range which lead to overflowing of low volume water courses (EMA, 2001). In recent years, there have been severe flooding events in various localities which have led to significant damage to livestock, agricultural produce, homes and businesses. The recurring problem is attributed mostly to inappropriate land use practices particularly related to deforestation and clearing of vegetated areas which include slash and burn agriculture, illegal logging, forest fires and illegal settlements which make lands vulnerable to erosion, rapid water runoff and slope failure (Ramlal & Baban, 2008). Estimates from the Trinidad & Tobago National Forestry Division indicate that over 17,000 hectares of vegetated areas were burnt by 1746 fires in the period 2008-2013. Approximately 20% of the fires were started for agricultural purposes and 35% were deemed malicious in origin.

Vegetation type	No .of fires	Percent	Area burnt	Percent
Natural forest	50	2.9	1564.1	8.9
Secondary forest	288	16.5	2935.6	16.6
Teak plantation	133	7.6	5262.7	29.8
Pine plantation	80	4.6	780.3	4.4
Agricultural lands	363	20.8	1775.6	10.1
Savannah/grasses	721	41.3	4702.5	26.6
Other	111	6.4	629.7	3.6
TOTAL	**1746**	**100.0**	**17650.5**	**100.0**

Cause of Fire	No. of fires	Percent	Area burnt	Percent
Agriculture	370	21.2	4719.4	26.7
Debris	128	7.3	1135.2	6.4
Hunting	17	1.0	87.2	0.5
Smoking	89	5.1	366.3	2.1
Other	26	1.5	322.6	1.8
Malicious	614	35.2	6081.7	34.5
Unknown	502	28.8	4936.3	28.0
TOTAL	**1746**	**100.0**	**17648.7**	**100.0**

Figure 4. Distribution of fires by vegetation and source[70]

Much attention is paid in the disaster literature to large scale catastrophic disaster events, obscuring the more localized medium and smaller scale struggles with hazard and risk faced by the most vulnerable in societies which have corrosive effects on livelihoods, assets and impedes pathways to sustainable development (Pelling, 2003; Wisner et al., 2004). Because of its geographical location at the southern end of the Caribbean archipelago - off the traditional path of hurricanes - and its mountainous topography which buffers against storms, the island of Trinidad has experienced 9 major natural disasters over the period 1889-1999 and 3 major

[70] Compiled by author from data made available from Trinidad & Tobago National Forestry Division, 2014.

flooding events from 1992-2002 not experienced nationwide catastrophic losses related to extreme storm events or cyclonic activity compared with neighboring islands in recent times[71].

With a changing climate, the mean annual temperature is projected to increase by 0.7 degrees Celsius to 2.6 degrees Celsius by the 2060s and 1.1 degrees C to 4.3 degrees C by the 2090s relative to 1961-1990 averages for Trinidad & Tobago. Additionally, sea-level is projected to rise between 0.13m – 0.43 m under the B1 scenario and 0.18m to 0.56m under the A2 scenario by 2090 (GovTT, 2011). Projections also indicate a decrease in mean annual rainfall. However, the frequency and intensity of severe rainfall events are also predicted to increase, exacerbating the problems of flooding and landslides. In recent times, Trinidad has experienced notable localized changes in encroachment rates of the sea, accelerated coastal erosion rates, high energy storm surges and repeated flooding and landslide events in several rural and urban coastal communities (CANARI, 2012; Darsan, Asmath, & Jehu, 2013; Gray-Bernard & Chadwick, 2009). Additionally, several of the country's critical wetland, marine and riverine ecosystems and dependent socioeconomic sectors such as fisheries, tourism and agriculture are showing signs of stress to environmental and climatic changes which occur over longer time scales (GovTT, 2011; Singh, 1997). However, studies on the localized socio-economic impacts and adaptations to these changes have not been explored or integrated with existing environmental models (Michael Sutherland & Seeram, 2011; Michael Sutherland & Singh, 2013).

This dissertation seeks to identify in one socially and ecologically vulnerable region of the island, not only the physical outcomes of exposure to climate related hazards, but to provide

[71] For example, the Windward Islands, Haiti and Jamaica.

insight into the social and institutional dimensions of coping and responding to threats which are predicted to intensify in the future. The Turtle Region was selected as the case study site because it satisfied several conditions: (i) serious, immediate threats to infrastructure and or natural environments (e.g. tourism infrastructure, natural resources, habitats, species) (ii) threats to vulnerable area residents (e.g. livelihoods, family structure, cultural assets, and vulnerabilities derived from poverty/gender issues) and (iii) opportunities for partnerships and alliances with focal community-based organization. Experiences from this region can be potentially transferred to other similar contexts and reveal, more broadly, the differing states of risk, vulnerability, capacity and resilience operating at a local scale.

The Turtle Region

The Turtle Region is a remote and impoverished coastal region in the county of St. David in Northeast Trinidad. The settlement history of the region is atypical of many rural settlements in the Commonwealth Caribbean, which usually relate directly to the colonial plantation patterns, because the area was too mountainous and wet for sugarcane cultivation (Richardson, 1975). Initially populated by small Amerindian groups and missionaries, the Region became a cotton and cocoa production node. With the eventual decline of cocoa in the 1920s and 1930s and construction of a new road which allowed improved access to the capital Port of Spain, the villages experienced a decline in population as residents emigrated out of the region (Harrison, 2007). However fishing and agriculture continued and the region remained largely self-sufficient with a wide array of shops, services and cultural activities (Anthony, 1988; McIntosh, 2002). Today, fifteen small fishing and agricultural villages connected by a 55.3 km long

(34.36 miles) winding coastal road make up the Turtle Region[72]. Once considered the food basket of the country, the area witnessed the collapse of large-scale agricultural estate productions and subsequent lack of investment from successive national governments, and is now one of the poorest regions in the country (McIntosh, 2002) .

A total of 7,267 persons live in the Turtle Region and the average number of households is 115[73] (CSO, 2011). The majority are of African descent, with some families of Indian and Chinese descent. Several religious denominations exist including Roman Catholic, Anglican, Seventh-Day Adventist, Pentecostal, Moravian and Spiritual Baptist. In the past, there was a sense that the region was closely connected through social institutions such as familial ties, religious affiliations, village councils and community groups. Households are often related within and between villages, with the nuclear family and extended family institutions regarding as an important element of community life. However, a growing generation gap exists between the adults and youths as the communities, and there has been a decline in the prominence of elders. Community groups work to continue the tradition of community unity and also serve as an important source of assistance to those most in need (Reddock, Reid, & Parpart). Most villages still have a Village Council[74] to represent villages on political and planning platforms as well as coordinating inter and intra community activities and events. Each community may have 1-2 active local groups where environmental programs and projects are often the primary

[72] Also known as the 'Toco Region' or 'Matura to Matelot Region'.

[73] The largest village – Matura – has a total of 383 households and the smallest village – Mahoe – has a total of 23 households.

[74] The influence of the Village Council varies among villages as some councils are operational, others are indefinitely inactive.

missions. However, their mandates often expand into other arenas based on the social protection needs of the community.

A prominent community group in the region is the Matura-based Nature Seekers which was founded in 1990 with the mission of protecting nesting leatherback turtles through tour guide services to Matura Beach and administering beach patrols. Over time, membership in the group transitioned from a volunteer basis to receiving funding from the Government to administer turtle conservation programs and promote greater awareness within the community. Tour guide services extended to hikes, nature walks and excursions through the forest and to waterfalls. The group's operations have diversified to include reforestation activities through the National Reforestation and Watershed Rehabilitation Program, waste recycling, community education and training, sustainable jewelry and crafts (www.natureseekers.org). In 2006, Nature Seekers joined five other community groups[75], the national Forestry Division and energy company BHP Billiton Trinidad & Tobago to form The Turtle Village Trust. The Trust works as a regional umbrella organization responsible for facilitating ecotourism partnerships between conservation groups and communities and administering the National Sea Turtle Monitoring Program (www.turtlevillagetrust.org).

The Paria/Toco Main Road, a winding two-lane arterial, which is bounded by the coast on one side and mountainous forested terrain of the Northern Range on the other, connects the villages starting from the settlement of Matura and ending at that village of Matelot. Although, it is the only access road in the region it is poorly maintained and at several points is being undermined

[75] Fishing Pond Turtle Conservation Group, Grande Riviere Nature Tour Guide Association, SOS Tobao and the M2M Network.

by erosive processes of the ocean. The road is traversed by personal vehicles, private taxis, public mini-vans and buses. There are 13 primary schools and 3 secondary schools in the Region and most residents have up to high school level education. However, many residents leave the region for educational opportunities or tutoring. Each village has a health center or clinic for minor check-ups. Serious medical conditions are treated at the Sangre Grande Hospital[76] or the Port-of-Spain General Hospital. Due to limited infrastructure, telecommunication services are limited to a few providers and intermittent service and most residents use cellular phones and access cable through Direct TV. Community centers offer access to Internet for a small fee (Reddock et al.).

The beach and coastal vegetation typically comprise of almond trees, coconut palms and strand vegetation (Mycoo & Gobin, 2013). The forested areas of the Northern Range consist of primary and secondary tropical rainforest, with Mora species as the most dominant and a large portion consists of a national forest reserve. Agricultural land use is confined to the floodplains of major rivers and coastal lands adjacent to settlements. Fertile river valleys produce food crops such as cocoa, bananas and citrus, while coconuts are grown on the coastal strips (Planviron & Touristics, 1999). Much of the agriculture takes place in unregularized patterns on state and abandoned private land[77] often employing slash and burn practices and overusing pesticides.

[76]1-3 hours away depending on the village; 2-4 hours away depending on the village.

[77] Residents also tend small vegetable gardens in backyards or nearby lands.

Many of the beaches serve as landing areas for inshore and artisanal fishing vessels and most fishing is carried out near established fishing depots at Saline Bay, Balandra, Cumana, Toco, Grande Riviere and Matelot. The northeast coast is a high productivity zone influenced by the inshore upwelling system associated with the Caribbean Current which supports rich fisheries of pelagic and demersal stocks including , shark, kingfish, swordfish, shrimp, salmon and snapper and grouper (Dhoray & Teelucksingh, 2007; Mycoo & Gobin, 2013). Sea moss[78] farming occurs along the stretch of coast between Sans Souci and Matelot and shrimp and salmon aquaculture is also practiced on a small scale (Planviron & Touristics, 1999).

Land tenure insecurity, land fragmentation, inadequate infrastructure, limited road access and lack of markets for non-traditional export crops serve as barriers to pursuing agriculture as a main livelihood (Planviron & Touristics, 1999). Decline in size and extent of fish stocks, income insecurity and challenges associated with prohibited fishing seasons during turtle nesting seasons deter younger residents from pursuing fishing as a single livelihood. Additionally, the government sponsored Unemployment Relief Program provides approximately 10 day intervals of employment in road words, landscaping, beach clean-ups. The program offers an intermittent alternative to agricultural and fishing livelihoods since the wages are higher and hours are shorter.

In the Tourism Master Plan Study (1995) for Trinidad & Tobago the North-East coast was identified as a pristine, valuable asset for boosting tourism for the national economy. The region is noted for outdoor recreation, boutique hotels and eco-resorts and get-away second

[78] Sea moss contains agar which is used industrially as a thickener in processed foods. It is also used in fabric and leather manufacture, pharmaceutical products and biological labs.

homes. The interior forests house diverse natural resources and habitats including rivers, waterfalls, springs, pools and flora and fauna. Visitors looking to escape the hustle of town life engage in hiking, camping, river bathing, hunting, wildlife watching, sightseeing and research. High energy waves pre-dominate the region during November to April which coincide with winter activity in the North Atlantic from May to October, there are moderate-energy waves which allows for recreational swimming, surfing and rock fishing.

Bounded by the Caribbean Sea to the North and the Atlantic Ocean to the East, the Turtle Region is also known as one of the world's densest nesting sites for marine turtles[79] and a significant site for nesting in the Caribbean[80] (Eckert, 2013). A budding eco-tourism niche industry has developed around the presence of scenic bays, beaches and reefs, highly diverse endemic flora and fauna[81] and the annual migration of mostly Leatherback turtles to their natal shores to nest between March and August[82] (Harrison, 2005). Three of the world's seven species of sea turtles which come to nest on Trinidad & Tobago's shores have been listed on the IUCN Red List of Threatened Species[83] and five species were designated as Environmentally Sensitive Species in 2014 by the Trinidad & Tobago Environmental

[79] Grande Riviere beach which is only 0.8 km long and 28m-60m wide, hosts approximately 3000 or more turtles.

[80] 88% of leatherback turtles nesting estimated in the Caribbean use the beaches of Trinidad.

[81] Trinidad Piping Guan known locally as the Pawi; Red Howler Monkey.

[82] The Ministry of Planning and Development indicates that annual visitors to the Grande Riviere beach (based on the numbers of permits issued) average 3500 and in 2006, there were an estimated 10,000 visitors to Grande Riviere (excluding the number of one-day visitors to the community).

[83] *Dermochelys coriacea* (Leatherback) listed as vulnerable, *Lepidochelys kempii* (Kemp's Ridley) listed as critically endangered and *Lepidochelys olivacea* (Olive Ridley) listed as vulnerable (www.redlist.org).

Management Authority. A natural resource co-management arrangement with villagers, community based organizations and government agencies was established in 1989 and in 1990 three beaches[84] were designated as Prohibited Beaches where permits are required to access these beaches during nesting season and hunting or taking of turtles / eggs is punishable by law (Lee Lum, 2002).

The turtle nesting season has grown in popularity over time. The total number of visitors from 2000-2013 was 216,368 and permit sales to enter the prohibited beaches has increased from approximately $57,000 for 540 permits to $94,000 for 4504 permits (Poon, 2013). The growth of the eco-tourism market provides a link between conserving natural resources while creating albeit temporary employment and revenue-earning opportunities for the local communities[85] (Lee Lum, 2002). These jobs were a direct result of the major ecotourism activities revolving around the leatherback turtle. Indirect jobs related to conservation[86] are state-funded and linked to the Unemployment Relief Program (URP); the Community-based Environmental Protection and Enhancement Program (CEPEP); and the National Reforestation and Watershed Program. Approximately ten community groups work to protect Turtle populations supported by the Forestry Division and revenue allocation of over $5 million TTD (Poon, 2013). In spite of progress in protecting turtles in their nesting beaches, anthropogenic pressures such as illegal poaching of turtles and harvesting eggs, accidental by-catch in gillnet fishing nets, boat collisions, pollution, sand mining and coastal and beach front development have threatened the

[84] Matura Beach, Grand Riviere Beach and Salybia Beach.
[85] For example in Grande Riviere, with approximately 55% of 147 households unemployed, tourism resulted in the direct creation of 80 jobs for villagers in 2006 (Mycoo and Sutherland, 2011).

[86] Conservation groups and villages serve on nocturnal beach patrols, collect morphometric information, document mortality sources, assess population trends and behavioral patterns. (Audroing, 2014))

viability of Trinidad's Leatherback turtle populations over the past 10 years (Eckert, 2013; Mycoo, 2013).

A direct impact of sea level rise in low lying coastal areas includes the cycle of flooding and erosion on the beach which can result in increased mortality of turtle eggs and consequent loss of beach as a turtle nesting site. As a result of its physical and socioeconomic sensitivity to sea level rise and coastal flooding, Grande Riviere has been selected as a monitoring site for the Institute of Marine Affairs since 2000 to investigate rates of coastal erosion and sea level changes (www.ima.gov.tt). The International Community-University Research Alliance (ICURA) initiative also constructed sea level rise models for Grande Riviere using spatial[87] data and tide gauge data collected from 2009 to 2011 (Michael Sutherland & Seeram, 2011). Projections indicate that a 0.4m- 0.6m rise in sea level can lead to loss approximately 2,060 m^2-2,900m^2 either to inundation or beach retreat leading to loss of approximately 44%-60% of nesting areas for leatherback turtles and private property boundaries which can have economic impacts on the community dependent on this biological resource and activity (Sutherland and Seeram, 2011; Sutherland and Singh, 2013). Simulations of 0.8m sea level rise projects a loss of approximately 3,200m^2 of turtle nesting habitat, private property and physical infrastructure and beach hotels begin to be impacted. These simulations indicate that sea level rise could potentially negatively impact he nesting impacts and the overall socioeconomic well being of the community which depends upon the turtles' presence (Mycoo and Sutherland, 2010; Mycoo and Sutherland, 2011: Sookram and Sutherland, 2011).

[87] Topographic, hydrographic primary data and secondary spatial and thematic data processed in Arc GIS.

Figure 5. Map of Trinidad highlighting the Turtle Region

Survey and Workshop Communities

Three villages were selected as representative cases to perform the household survey and workshop – Matura, Sans Souci and Matelot. Although located within the same region and having similar demographic and economic characteristics, the communities vary in population size, geographic location and livelihood profiles. Within each community there is also the presence of an active community based organization working on community development. Variations between these villages will enable comparisons to be made regarding spatial and social exposure as well as coping responses and adjustments which occur when faced with similar extreme events.

Matura

The first village when entering the Turtle Region is the settlement of Matura which is a total of 6,557 hectares and a population of 1,772 (CSO, 2011). It was developed as an early Amerindian settlements and has been long known for its dense unbroken forests. With the opening of the Toco Main Road greater movement into Matura occurred from neighboring settlements. The village has grown into a mid-sized linear settlement along the main road. Unlike other settlements in the Turtle Region, Matura Village is situated inland, approximately 1.75 km from the eastern coast. The area is generally flat to gently sloping and approximately 30 meters above sea level (Planviron & Touristics, 1999).

The settlement primarily relies on agriculture, fishing, forestry and hunting as sources of economic livelihood. Quarrying, sand mining[88] as well as the forestry[89] sectors also employ residents. The village is also enclosed by the Matura Forest Reserve to the north and the Manzanilla Windbelt Forest Reserve to the south. Agricultural estates are situated along the flood plains of Matura River where cocoa, citrus and food crops are grown. Coconuts thrive on the coastal lands east of the village.

A boutique eco-tourism based sector is growing as a significant tertiary sector. The primary NGO organization, Natureseekers, organizes trips to Matura Beach for turtle watching as well as other recreational hikes, excursions and nature walks. Natureseekers also promotes local arts and crafts niche markets for domestic and eventually international markets as well as youth training and development activities.

[88] There is a sand processing plant which provides raw material for glass manufacturing by the Carib Beer Brewery.

[89] Timber is extracted from private forests and taken to three saw mills in the village. Residents also work to replant and rehabilitate degraded forests as part of the National Watershed Reforestation Program administered by Trinidad & Tobago Ministry of Environment.

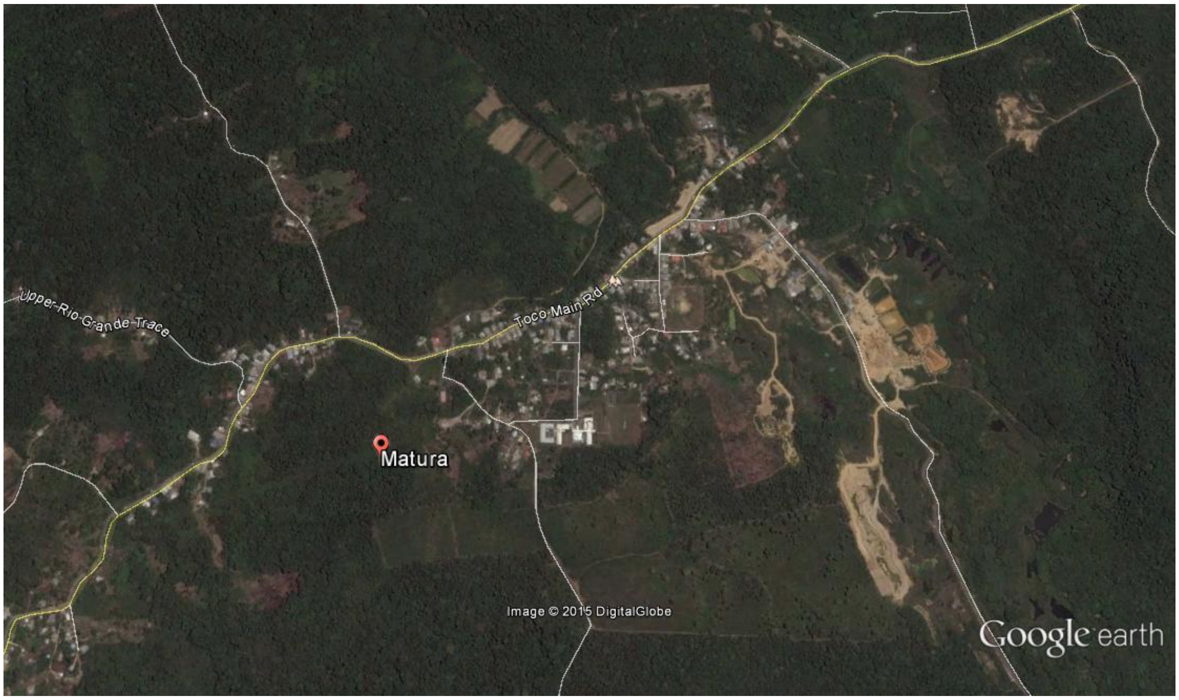

Figure 6. Aerial view of Matura Village settlement

Sans Souci

Sans Souci is a small linear settlement of approximately 585 persons along the North coast of the Turtle Region (CSO, 2011). The village developed around Sans Souci Bay on low lying coastal slopes. Beyond the coastal plain, the land becomes extremely steep and dissected by the De Four and Sans Souci rivers. The main form of development is housing and private beach houses on private and state lands. There are also State agricultural estates of banana and cocoa.

Sans Souci residents work primarily agriculture, fishing, sea moss farming and with government through the Community Based Environmental Protection and Enhancement Program[90]the Reforestation Program or with local / regional government agencies.

[90] Workers work 5-10 days per session on primarily infrastructure maintenance, drainage cleaning, clearing of debris.

The Sans Souci Tourism and Wildlife Development Organization was formed to develop the Sans Souci community socially and economically. They are working to develop an eco-tourism sector mostly around the nesting of the Leatherback turtle on beaches in Sans Souci. The organization is also the developers of the first community-based climate change adaptation pilot project in Trinidad & Tobago. The project is funded by the UNDP-Global Environment Fund Small Grants Program and aims to develop educate the community about the risks posed by climate change and identify ways to increase adaptive capacity through sustainable environmental resource management and practices within the Sans Souci community.

Figure 7. Aerial view of Sans Souci Village settlement

Matelot

Matelot is the most isolated village on the north coast of the Turtle Region. It is a linear settlement, confined to the Paria Main Road with a population of 550 persons (CSO, 2011). The main economic activities of the village are agriculture and fishing. Of the three case sites, Matelot is the only village with a fishing depot where the bulk of fishing landings occur. Most of the fish caught is taken by middlemen to market in the capital Port of Spain. The hinterlands of Matelot are excessively steep and it protects the village from any flooding associated with the Matelot River. The Dorca's Women's Group and the Matelot King Fisherman's Association are the main community groups working to advance the welfare of the Matelot community however given the limited resources and capacity of these organizations, the conditions in Matelot are in decline.

Figure 8. Aerial view of Matelot Village settlement

Chapter 8 . Findings

Spatial Impact Assessment of Extreme Events[91]

Characterizing the spatial aspects of hazard exposures and impacts are necessary for understanding the range of coping and risk reduction strategies which can evolve with the unique socio-ecological conditions of a community. The spatial dimensions of a single event can vary across temporal and geographic scales making the process of defining the nature of exposure in a given region to be dynamic at best. Attention to officially recording events and impacts can improve the level of analytical precision yet larger-scale and more recent impacts tend to overshadow the more subtle and long term impacts that may be occurring independently or concurrently. In regions which are data poor, emphasis is placed on the collection of local observational evidence to develop qualitative narratives of past and present vulnerability and risk. This can alter the timeframe over which information about past events can be accurately collected, however it widens the potential range of reportable events that could have occurred. Additionally, anecdotal evidence can give a richer description of the elements at play when extreme events occur as well as the severity of outcomes. The goal of this risk assessment is to qualitatively determine from recorded extreme events which affected the region, the risk factors which increase exposure to these impacts by integrating scientific data with local experiences and knowledge.

Two distinct yet often related hazards tend to dominate landscape of the Turtle region: riverine flooding and landslides. The Trinidad & Tobago Office of Disaster Preparedness and

[91] Photographs courtesy of Dennis Sammy and Elizabeth Monsegue.

Management (ODPM) modeled the country's susceptibility to flooding and landslides using Geographic Information Systems software and presented various hazard impact and risk assessments maps (ODPM, 2013). In the vulnerability map, much of the inhabitable areas in Turtle Region are characterized as having "moderate" to "very high" susceptibility to both hazards (http://www.odpm.gov.tt/node/246). However, when overlain with population and building density data, the overall vulnerability to flooding for most of the Region decreases to the "low" to "very low" risk. In the case of landslides, the extent of areas which are categorized as "moderate" to "very high" risk decreases significantly as well. A more detailed disaster map revealed the locations of areas which are at risk for experiencing repeated flooding and/or landslides (http://www.odpm.gov.tt/node/133). Finally, the hazard impact map presented two major flooding and landslide hazard events which impacted the region (http://www.odpm.gov.tt/node/245): Riverine flooding on October 30-31, 2010 impacted the villages of Matura, Balandra, Tompire, Cumana, Mission, Grande Riviere and Monte Video. Total daily rainfall recorded over the two days was 6.2 mm which is below the combined average daily rainfall during those days of 4.6 and 4.8mm respectively (TTMet, 2014). No persons were listed as impacted however, the major impacts were 3 flooded houses, major road blockages due to flooded roadways which were only passable by trucks/buses and a landslide which hampered resident road access. The second event occurred in December 3-4, 2011 triggered major landslides in Maya, Sans Souci and Grande Riviere. In Maya, the house was completely destroyed and a man was trapped. In Sans Souci, a house was also destroyed, however no injuries were reported. Roofs were partially or completely blown off in three unrelated high wind incidents on, September 19, 2010, January 10, 2011 and June 14, 2011. No injuries were reported.

The value of this type of mapping data cannot be underestimated as it provides important information for broader regional emergency preparedness and development planning and programming. However, it does little to highlight the interactions of risk factors which produce and increase overall exposure to hazard events. In addition, the metrics of lives lost or injuries reported do not adequately capture the extent to which people may be affected by the event. The localized experiences of impacts shared within and between communities are often uniquely realized. This study attempts to add additional layers of understanding beyond the "what" and "where" to evaluate the "how" extreme events are affecting the Turtle Region.

Regional risk factors

The site walk, interviews and focus group workshops revealed three primary factors interacting in direct and indirect pathways to exacerbate the overall risk of specific flooding and landslide events in the Turtle Region. First, the rugged yet coastal topography dually contributes to the natural beauty and hazardous conditions which define the vulnerability of this unique and rural socio-ecological system. The soils between Toco and Grand Riviere are formed from an isolated formation known as the San Souci Group which is separate from the geological formation of the Northern Range. The Group consists of sedimentary and igneous rock of Mafic sub-aerial volcanic and hypabyssal rocks, fine black shales, coarse quartzo-feldspathic sandstone channels, calcareous shales, grits and thin limestone bands (Neill et al., 2014). The prevalence of slope areas[92] with relatively steep inclines and these soils which tend to retain moisture increases the propensity of leaning and land slippage from higher elevation areas into populated areas below (Planviron & Touristics, 1999). A significant amplifying factor are the poor land use practices

[92]For example, Matura has 74 distinct slope areas and Matelot has 30 distinct slope areas.

particularly related to deforestation and slash and burn practices at higher elevations without reforestation (See Figure 9, Figure 10 and Figure 11).

Figure 9. Exposed hillside which is susceptible to sliding during rainy periods

Figure 10. Exposed and burned hillsides for small-scale farming

Figure 11. Exposed vertical slope where landslide previously occurred

The Turtle Region is dissected by several rivers and streams[93] which begin in the highlands of the Northern Range and terminate in the bays at the coast (See Figure 12 and Figure 13). The river systems[94] provide regional access to water supplies and tend to keep the soil moist or saturated. Retention ponds for agricultural activities and the expansion of utility lines create channels which also provide further saturation of the area. The villages are often situated in the floodplains of these rivers as these spaces are more suitable for agriculture and development. The restricted land availability in the region directly exposes housing, hotels, public assets and infrastructure to the threat of flooding once the waters breach their channels during intense and/or prolonged rainfall events. Deforestation, agricultural clearing and improper land use

[93] e.g. Matelot River, Grande Riviere River, Shark River, Matura River.

[94] Includes underground (often unknown) channels, streams and aquifers.

management also contribute to excess sediment entering the river, decreasing the overall depth of the channels and reducing the volume of water which can normally flow without flooding the banks.

Figure 12. Matelot River flowing into Matelot Bay

Figure 13. Grande Riviere River flowing into Grande Riviere Bay

The second factor is related to the region's limited infrastructure. The narrow Paria/Toco Main Road as well as associated bridges is the single arterial in the region which is physically exposed to the ocean at several points due to low lying topography, absent and/or degrading barriers (See Figure 15, Figure 16 and Figure 16).

Figure 14. Road reinforced by sea wall which is being undermined wave action

Figure 15. Portion of road in Big Bay-Sans Souci that is frequently flooded by high surges

Figure 16. Road running adjacent to ocean in Matelot

Many points along the road are narrow and in deteriorating condition, which when impacted by landslides or flooding further constrains access to villages before and after the impact site (See Figure 17 and Figure 18).

Figure 17. Sliding shoulder in Matelot

Figure 18. Large hole in road in Matelot filled after rain event

Portions of the road which are at higher elevations face the forces of gravity which tend to pull the earth along with the roadway towards the ocean (See Figure 19 and Figure 20).

Figure 19. Damaged roadway and rehabilitative structure

Figure 20. Protective structure to prevent sliding

The third factor is lack enforcement of development restrictions and setbacks. Access to developable land is constrained by the topography which encourages siting of housing, hotels and other properties in hazardous zones directly on or near to the beachfront, on river floodplains or adjacent precarious hillsides with propensities to slide (See Figure 21, Figure 22, Figure 23, Figure 24 and Figure 25).

Figure 21. Hotels on beach in Grande Riviere

Figure 22. House on stilts on separated from ocean by low wall

Figure 23. Housing on terrace exposed to ocean

Figure 24. Stilted house on a terraced hill

Figure 25. House below steep exposed hillside

Coastal erosion and high wave action were identified in all workshops and some interviews as hazard processes which were increasing in severity and threatening structures along the coast and the main road. The beaches in the Turtle region are considered to be dynamic and strong wave action is expected during certain times of the year. However, the rate of erosion and anomalous extremity of rough wave incidents have raised growing concern about the future stability of the North-North-East shoreline. A frequently cited incident of erosion and rough wave action was the damage of the Matelot fishing facility and boats on the landing which were destroyed by rough waves[95] in 2005 and 2013. The rough seas took a toll on coastal villages all along the northern and north-eastern coasts and were considered to devastating to the livelihoods of fisher-folk within the villages as several boats, nets and fishing equipment were destroyed or damaged.

[95] Generated by storm activity and high winds.

The profile for Grande Riviere beach has been monitored by the Institute of Marine Affairs[96], however profile changes for the rest of the region remain largely speculative and anecdotal[97]. Hotspots of erosion where the Paria/Toco main road is evidently undercut were identified along the eastern portion between the villages of Balandra and Redhead and the northern coast between Toco and Sans Souci as well as between St. Helena and Matelot[98] (See Figure 26 and Figure 27).

Figure 26. Erosion hotspot along East coast

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[96] Changes to beach profile can be attributed to different dynamic processes such as interactions with Grande Riviere river, ocean current flows and wave dynamics.

[97] Long-time residents indicate distinct and rapid changes in the beach profiles and high tides marks have occurred within recent times and note the disappearance of coastal landmarks, long-standing vegetation such as coconut and almond trees, cracks in building foundations.

[98] Portions of the road are being undermined and slipping.

Figure 27. Erosion hotspot along North coast

Risk heterogeneity

The common risk factors tend to overshadow the heterogeneous and localized nature of spatial exposure and impact. The workshops revealed an association between the location of the villages and the type and frequency of the events residents experienced and recalled. When asked about recent significant extreme events in the region, a single event would dominate the discussion of each workshop, but the events varied among the different workshops. The workshop in the Matelot community described the impact of landslides which occurred in November -December 2013 after periods of prolonged rainfall, where residents were stranded or locked out of their village following a mudslide between Grande Riviere and Matelot which made that stretch of the roadway impassable (See Figure 28). Workshop participants indicated that it was common knowledge that the potential for a slide was imminent, yet no preventative actions were taken. Once the slide occurred the Sangre Grande Regional Corporation (SGRC) made attempts to contain the loose earth, however major rehabilitative efforts would be required by the Ministry of

Works and Transport. In spite of a disaster declaration by the Office of Disaster Preparedness and Management (ODPM), complete removal of the slide took approximately three months. In the first few weeks, residents walked around the landslide to exit and enter the community.

Figure 28. Location of major landslide between Grande Riviere and Matelot

The Sans Souci workshop participants discussed the 2011 early morning landslide which claimed the life of a 67 year old man. The slide which damaged 15 other homes and displaced 20 families, completely covered the victim's home, leaving him trapped for hours. His wife and differently-abled daughter, escaped unharmed. The Sans Souci slide was one of ten slides which occurred in the region during an extended period of rainfall which last for approximately 24 hours. The multiple slides blocked access to the impacted villages and disaster response and rescue assistance from the Disaster Management Unit (DMU) could not be rendered in a timely manner. A team of neighbors and villagers tried to dig the victim out of the slide, but were unable to reach him because the earth kept sliding. His body was unearthed six hours after the incident, and extracted from the debris with the "Jaws of Life" hydraulic rescue device. During that same prolonged rain event, another major landslide occurred on the other side of the ridge which completely destroyed house and left a woman and her four children homeless. The source of the landslide material was identified to be mounds of exposed earth located above the house left there during construction project.

Another risk factor which was raised only in the Matura workshops was the prevalence of flooding events, which were blamed on the degradation of land by sand and gravel quarrying operations. These legal and sometimes illegal quarry sites face little regulatory oversight and are often abandoned, un-rehabilitated and starkly appear as scars across the forested landscape (See Figure 29). The largest quarry operation, is located approximately 0.12 kilometers (0.1 miles) from the Matura River and 1.29 kilometers (0.8 miles) from the coast. Workshop participants believed that removal of acres of forest cover increases the rate and amount of run-off and subsequent land contamination with quarry pollutants during heavy rainfall periods.

Figure 29. Quarry site in Matura

A review of impact data records available from the Regional Disaster Management Unit indicates some variability in terms of the types of events experienced based on the village's location (DMU, 2014). The majority of events reported included flooding, landslides, non-weather related events[99] and high winds respectively. Yet, there are limitations with the availability of accurate data, disaster event reporting processes and limited record keeping over longer time scales.

[99] Non-weather related events include event not directly attributed to a particular weather event including loss of electricity, fire, collapsing structures, tree falls.

Year	Village	Event	Reported
2010-2014	Matura	Flood	2
		Landslide	1
		Wind	2
		Erosion	0
		Non-weather	3
		TOTAL	8
2013-2014	Matelot	Flood	0
		Landslide	5
		Wind	0
		Erosion	1
		Non-weather	2
		TOTAL	8
2010-2013	Sans Souci	Flood	8
		Landslide	7
		Wind	1
		Erosion	0
		Non-weather	4
		TOTAL	20

Table 2. Impact data for Matura, Sans Souci and Matelot 2010-2014[100].

Within the three case study villages, Matelot, which is located in the higher elevations of the Northern Range appears to be the most at risk to flooding and landslides. The risk appears to be greater in areas en route to the village rather than within the footprint of the village. This is a significant problem for Matelot given the village sits at the end of the main road with no alternative route out of the area and can be essentially cut off for extended periods. Loss of low lying coastal zones via sea level rise does not pose as significant a risk. Conversely, much of Sans Souci is located close to sea level and the village faces significant exposure to coastal erosion, storm surges and sea encroachment. Since there was a large landslide in Sans Souci and there were multiple instances of slipping land – such as leaning poles, leaning trees, leaning

[100] *Note*. Compiled by author from DMU. (2014) *Matura to Matelot impact data*.

houses - the risk of landslides occurrence appears to be high as well. Matura village, which is located inland but surrounded by heavily degraded land, within the floodplain of the Matura River, is at high risk of riverine flooding. The Matura Beach, which is 1.75 kilometers (1.1 miles) away from the settlement is a long narrow sandy strip is directly exposed to the force of the Atlantic Ocean high energy waves and faces significant risk to coastal erosion and sea level rise and exposure to hurricanes. However, the realization of this impact may be more significant to the segment of the population who depend on Turtle nesting as a livelihood source.

Analysis

The Turtle Region faces several hazards which can simultaneously impact multiple localities during one extreme event. The risk tolerances that households in the Turtle communities exhibit when exposed to these natural hazards are not irrational or unique. Much of the vulnerability the flooding, landslides and coastal erosion hazards are a function of the physical features of the region – variable mountainous and low lying topography, unique soil conditions, a densely forested watershed and dynamic beach systems. These physical features also provide fresh water supplies, fertile agricultural land, ecosystem provisioning and regulating services and landscapes that support niche tourism economies and other subsistence livelihoods. However, non-physical factors related to land use and quality of infrastructure intersect to amplify the overall exposure and destabilizing impact on populations who are already exist on socio-economic and political margins.

The construction of the Toco/Paria main road, the accompanying drainage systems and coastal protections improved accessibility and connectivity within and outside of the region. However, such infrastructure were developed over fifty years ago to facilitate animals and carts taking goods from the region to town and are upgraded to substandard levels on a reactive basis only when a portion of the infrastructure fails. The patchwork of fixes on poorly constructed infrastructure is a condition beyond the immediate control of the affected communities because monitoring, assessments and repairs are the responsibility of government agencies. Yet political activation from these communities has opened spaces for social justice movements to demand government assistance to attend to the problem of deteriorating infrastructure.

The annual frequency with which these events are occurring, often in the same vicinity of previous events, help target problem areas which should receive priority remedial attention. However, the general consensus is that these are temporary fixes to a rural infrastructure system which needs to be extensively modernized. Ironically, even though the costs of cleaning up after each extreme event are high, the investments required to upgrade all vulnerable portions of the road and install appropriate shoreline mitigation measures in the region is also regarded as practically and politically unattainable. Even if this improbable scenario of upgrading or re-routing the Turtle region's transportation, drainage and mitigation infrastructure were realized, the second amplifying factor of poor individual and collective land use decisions would diminish the effect of any improved infrastructure and remedial systems. Similar to the traditional narrative of the very poor and the very rich tending to accept greater risk by selecting hazardous sites to construct housing, the people of the Turtle region, operating within a collage of public /private and protected /non-protected land arrangements, often construct in precarious and hazardous places. Although some design features are common across the region[101], the building

[101] Houses raised on stilts; Building houses on terraces.

codes, quality of construction and materials used vary widely. The value of ocean facing property in the region is growing as the area is increasingly becoming a retreat/resort getaway for locals in more urban areas. As a result, development on the coast of higher value homes, guest houses and resort properties are expanding in a somewhat oblivious manner to the risks faced[102]. On the other end of the spectrum, poor local households often occupy sub-standard housing on land that is available and/or where rent is affordable without the protections of insurance.

The land-use problems in the Turtle region are also embedded in multiple and ongoing conflicts between the sustainability of small-scale local livelihoods and the macro-scale pursuits of extractive industries. The remoteness of the region also enables individual and corporate land use practices to occur with little oversight and enforcement. Squatter settlements persist in the forested state lands of the Matura Forest Reserve despite repeated demolition and relocation actions by the Government. Agricultural slash and burn practices are difficult to patrol as people are easily able to shift locations and resource limitations of enforcement agencies. Although legal quarrying operations are required to submit applications to the EMA for Certificates of Environmental Clearance to perform quarrying and mining operations, illegal quarrying also takes place within the watershed and are difficult to remediate and reforest. Unless practices which accelerate land degradation are addressed by regional and national authorities, the local conditions which exacerbate the impact of extreme events will persist.

[102] Perhaps because they are able to procure property and casualty insurance to protect assets in the event of loss.

The impacts of extreme events vary across time and space. When thinking about the susceptibility of a small area like the Turtle Region to hazards that can be exacerbated by climate change in unpredictable pathways, the variances of exposure, impact and responses are often conflated into a single picture. However, this assessment reveals that although the regional risk factors are similar, the mosaic of outcomes is realized in different spatial patterns. As a result, policies which aim to adapt to new conditions must be appropriately differentiated to meet the specific needs of the affected communities but also fit into a broader integrated regional climate risk management framework. In order to understand the social variances within communities, the next phase in the assessment evaluates the social dimensions of impacts and responses to extreme events.

Social Impacts of and Responses to Extreme Events

Climate related hazards and extreme weather events pose serious risks to the viability of coastal households and their livelihoods. This section presents results from the climate extremes and disaster resilience household survey conducted during Summer 2014 within the case study communities of Matura, Matelot and Sans Souci. It begins by presenting the demographic and socio-economic characteristics of the households of the survey respondents. The purpose of this survey was to evaluate the experiences of households exposed to climate related hazards and weather extremes and the coping strategies employed in the short and long term. The literature previously reviewed identified variables such as gender, age, marital status, educational attainment, household income, livelihood activities, and land tenure status which can influence household exposure, vulnerability, coping and adaptive capabilities in the face of environmental stress or shocks. The results of interpretive statistical analyses[103] are presented on the impacts and response measures taken prior, during and after an extreme event occurs. These descriptive statistics help to identify which variable relationships are statistically significant and the general strength of the relationships among variables. Although conclusions about casuality and direction of the relationships cannot be made from this type of statistical analysis, from a policy perspective, identifying associations or trends of impact and responses related to specific demographic or socio-economic characteristics and/or conditions are important for informing targeted intervention strategies at the household and community levels.

[103] Fisher's Exact Test statistic was used to determine if statistically significant relationships exist in lieu of Pearson's Chi-square statistic since some cells had less than an expected count of 5 due to small sample size.

Descriptive Statistics

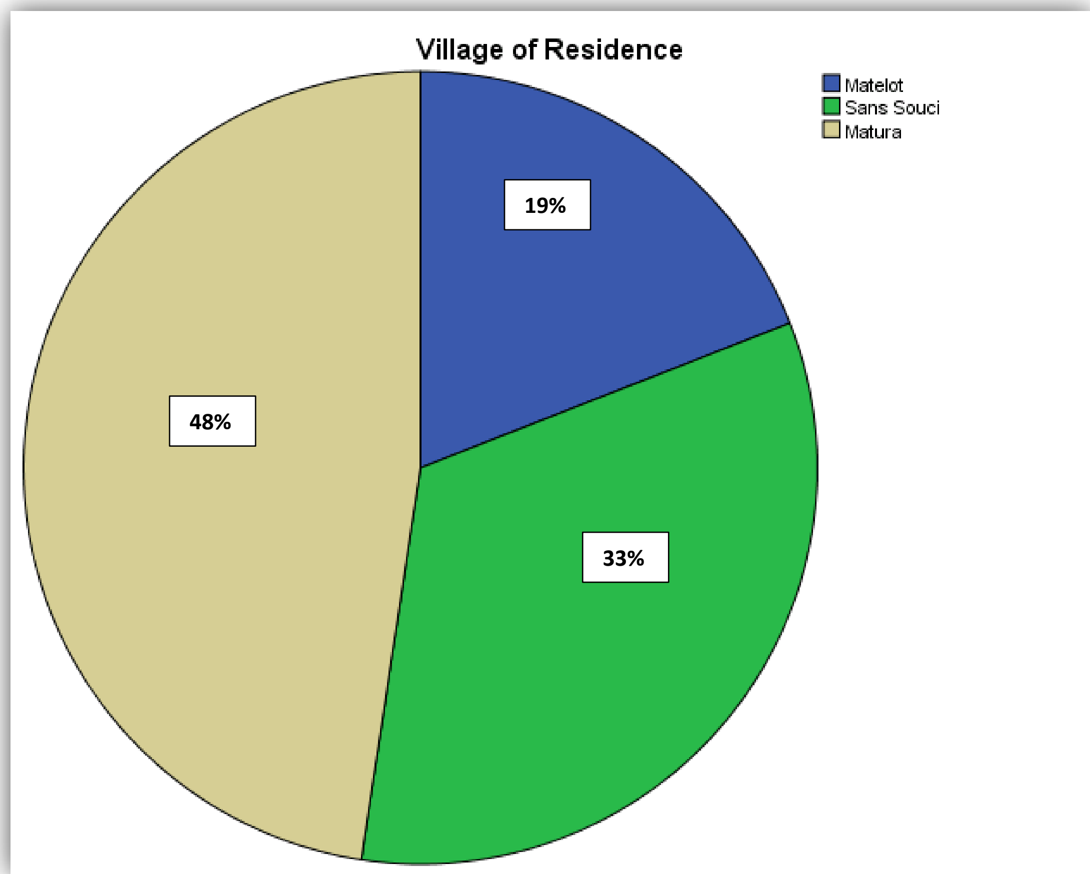

Figure 30. Percentage distribution by village of residence

Almost half of the 126 respondents lived in Matura (48%), 33% lived in Sans Souci and 19% lived in Matelot (See Figure 30). Given the communities of Matelot, Matura and Sans Souci are located in different geographic contexts, the way in which hazards are experienced may differ among the communities.

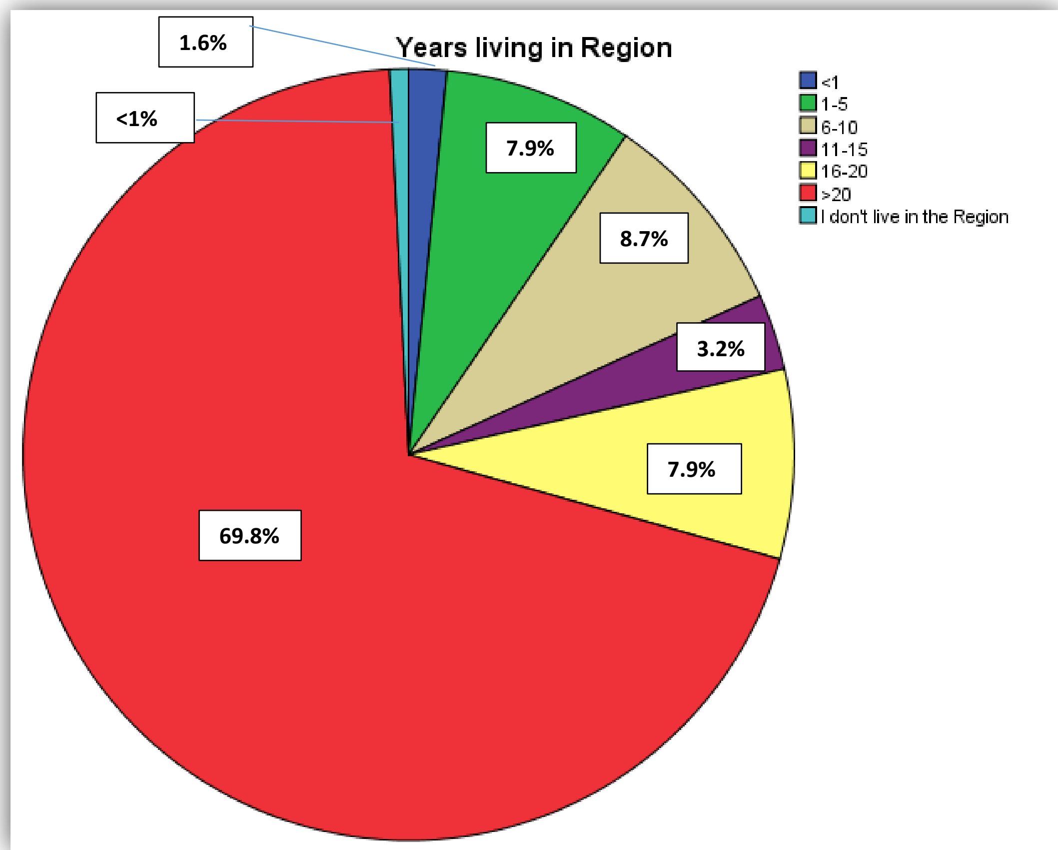

Figure 31. Percentage distribution of years living in Turtle Region

A majority of the respondents have lived in the region for over 20 years (approximately 70%), while approximately 30% of the sample have lived in the Region for less than 20 years (See Figure 31). Those residing in the region for a longer period of time may be more attuned to changes in the environment over time and experienced more events in the past compared with those living in the region over a shorter period of time.

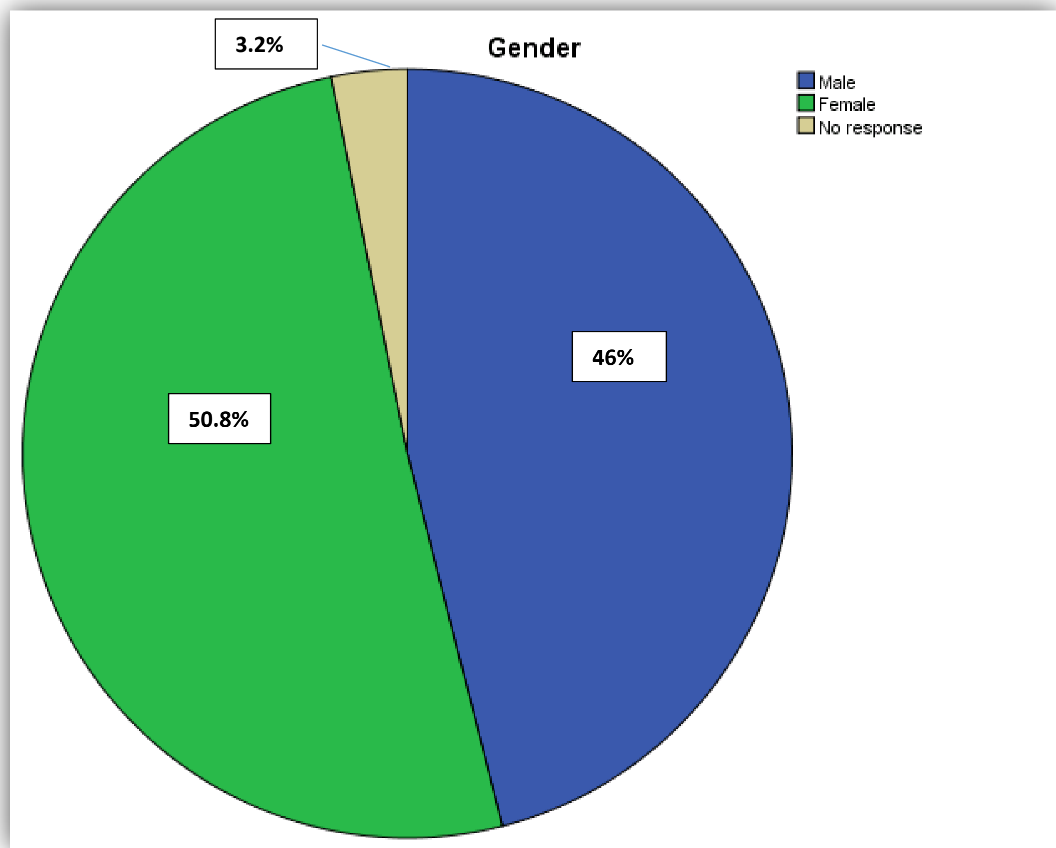

Figure 32. Percentage distribution by gender

Males and females were represented fairly equally in the sample where 58% of respondents identified as male and 64% of respondents identified as female (See Figure 32). The Caribbean is known primarily as a matriarchal society and there are often differences between men and women's perceptions, experiences and adjustments to stress, shocks and disasters.

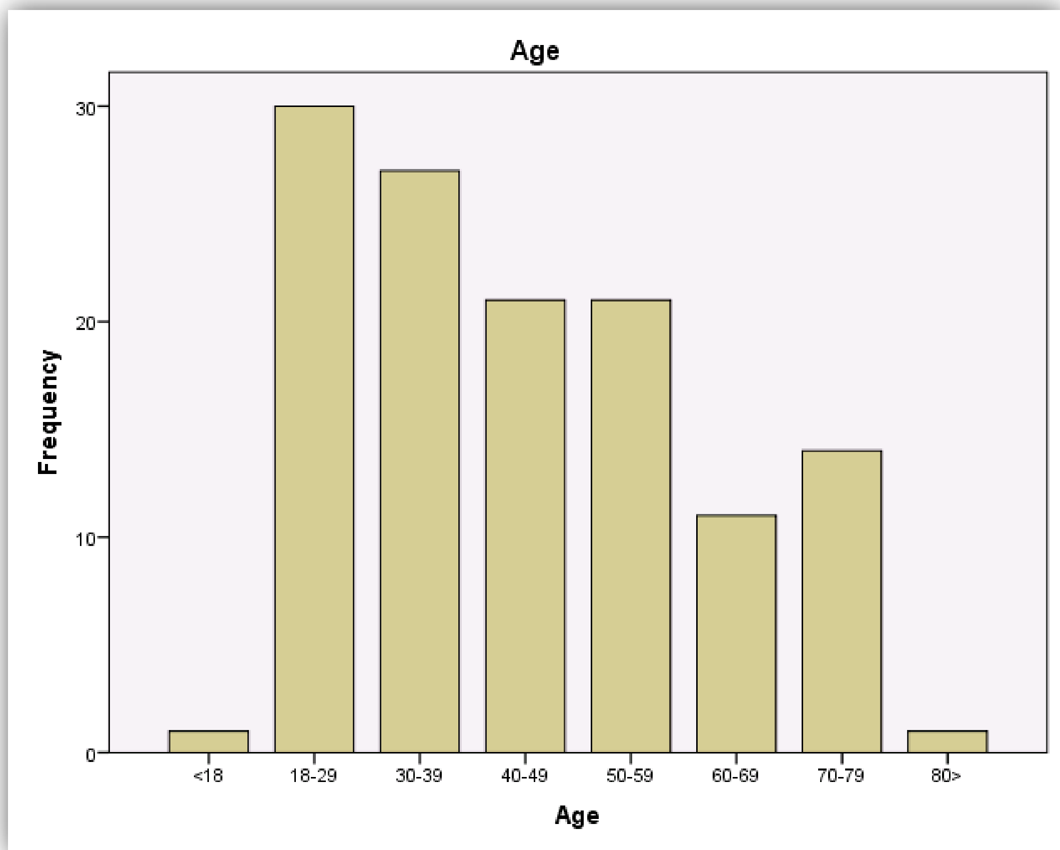

Figure 33. Age distribution

The age distribution is skewed to the left with most respondents falling in the 18-29 year age group (approximately 24%), followed by 30-39 year age group (21%) and 40-49 and 50-59 year age groups which were both (approximately 17%) (See Figure 33). This distribution is most ideal for the study, since the majority of respondents are of working age or have established livelihoods that may or may not have been impacted by a hazard or extreme event.

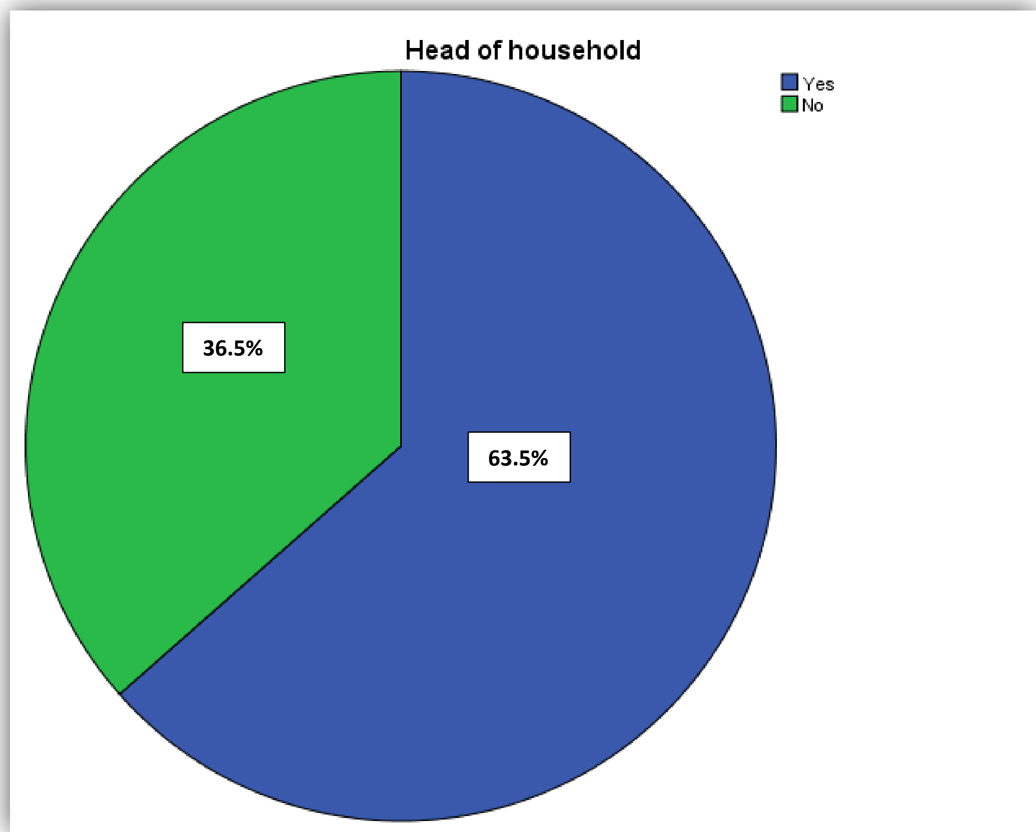

Figure 34. Percentage distribution of head of household

The majority of respondents identified as the head of the household (63.5%) while approximately 37% did not identify as the head of the household (See Figure 34). Heads of households are considered the primary breadwinners whose livelihoods when impacted can dramatically affect the state of household. They are also primary decision-makers who may influence behavioral responses, the level of preparedness and access to coping resources for the entire household.

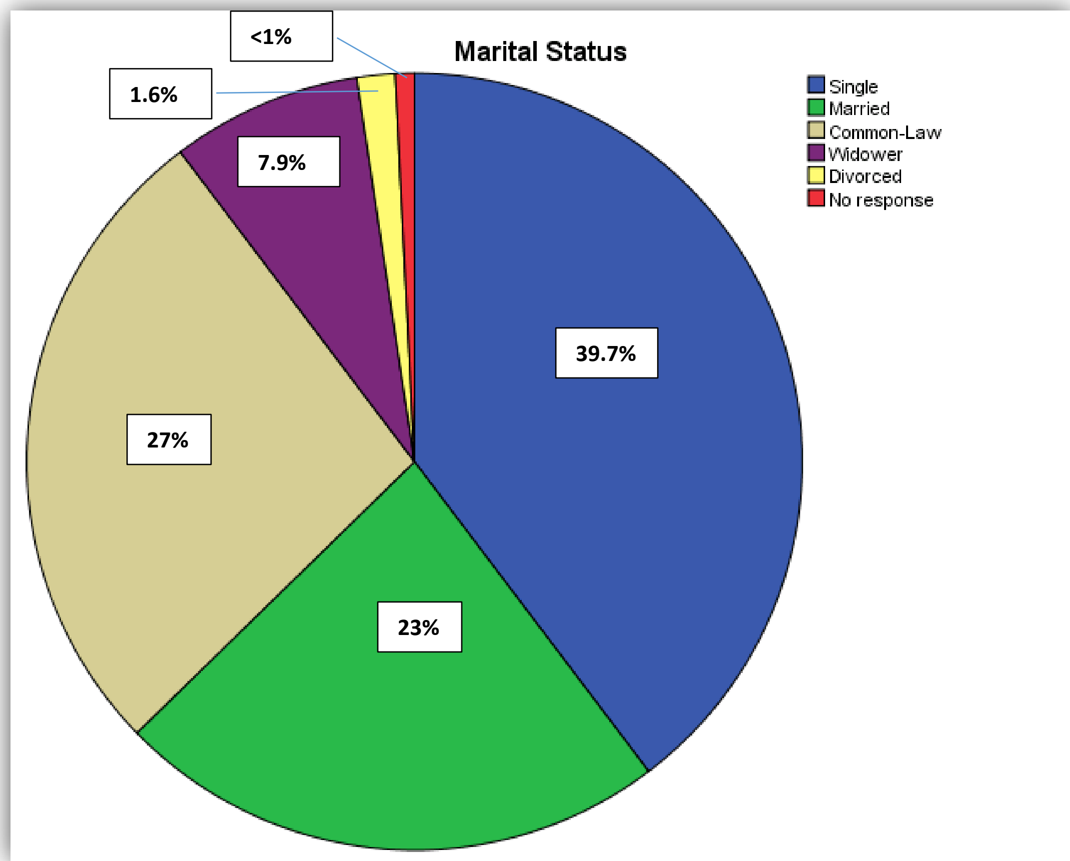

Figure 35. Percentage distribution by marital status

Most of the respondents were either single (approximately 40%), married (23%) or in a common-law relationship (27%) (See Figure 35). Households which have a couple in a relationship may have access to different types of resources than single-headed households.

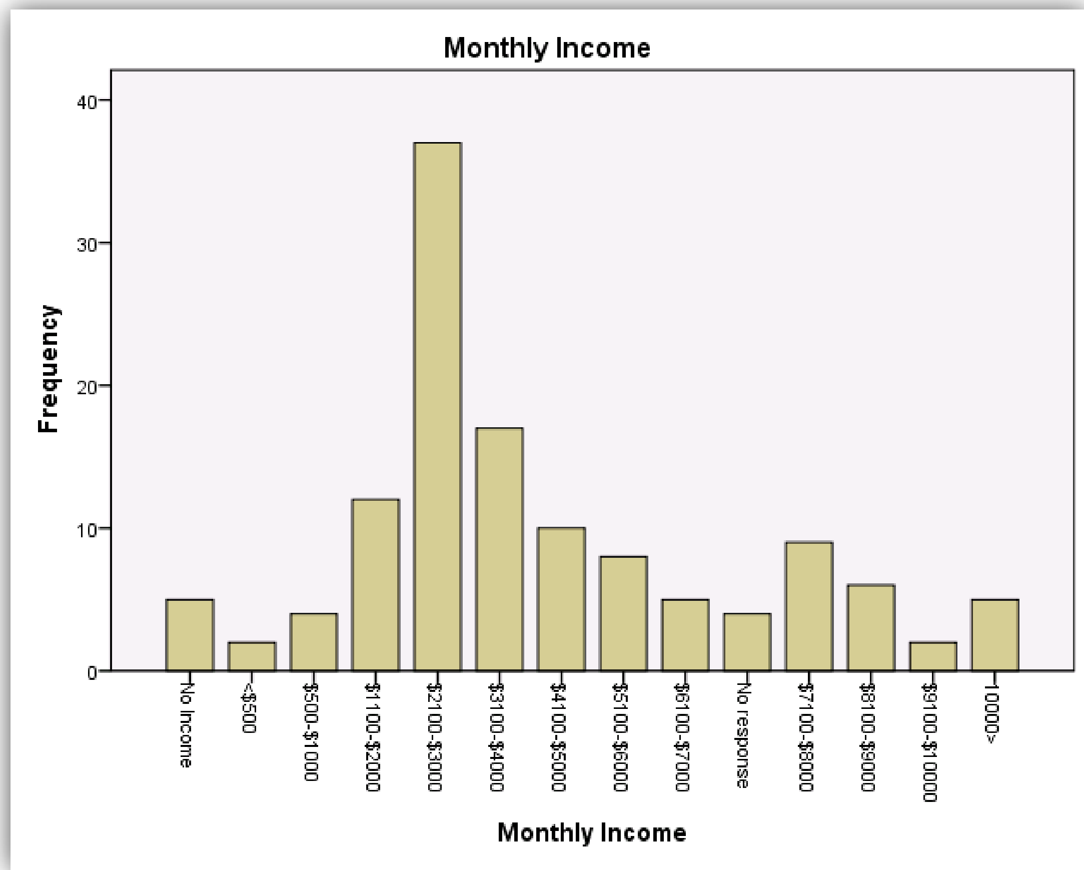

Figure 36. Income distribution

The most frequently reported monthly household incomes were between TTD $2,100 - $ 3,000 (USD $332 - $474) (29%) and TTD $3,100 - $4,000 (USD $490 - $632) (approximately 14%). Approximately 6% of respondents reported a monthly household income of less than TTD $500 (USD $79) and about 4% of respondents reported a monthly household income of over $10,000 (USD $1,580) (See Figure 36). This is an important variable which can determine household ability to absorb and recover from the impact of an event, through the purchase of resources and risk mitigation measures and savings vehicles and replacement of lost items, property or stock.

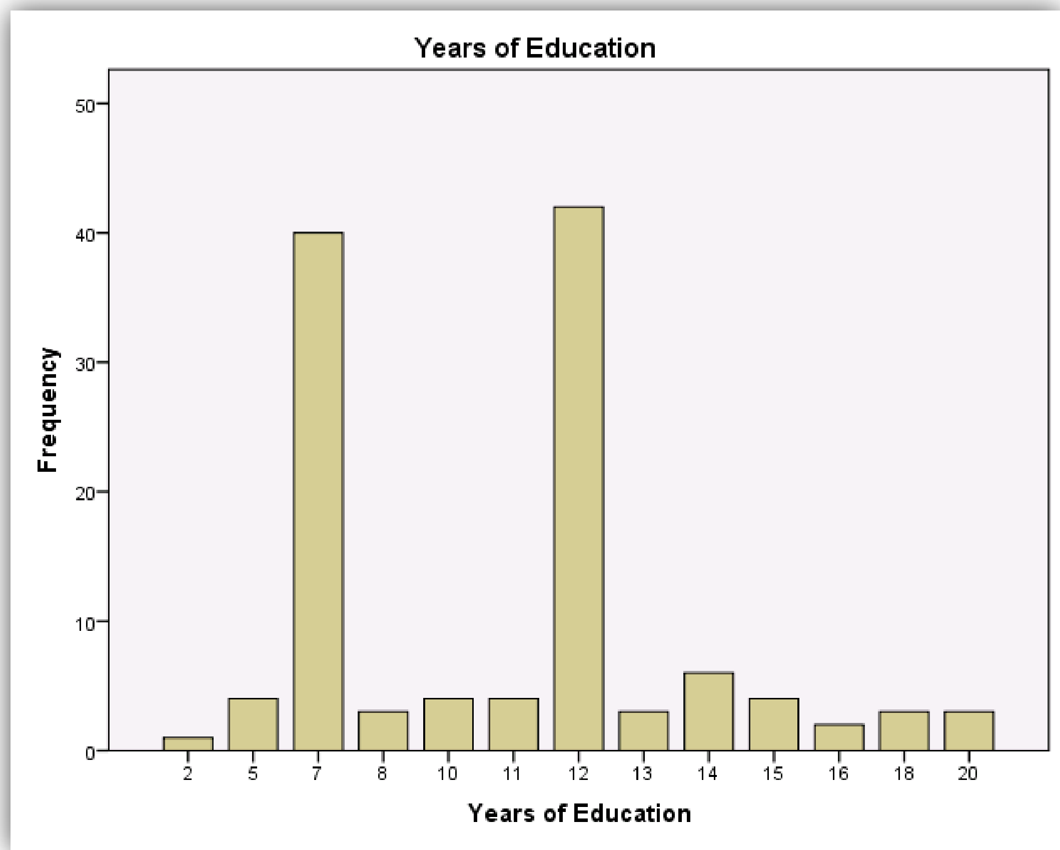

Figure 37. Years of education

The years of formal education ranged between 2 years at the minimum and 20 years at the maximum. The majority of respondents had up to a primary school (7 years) and secondary school (12 years) of formal schooling (32% and 33% respectively) (See Figure 37). Exposure to formal education can shape risk perceptions, ability to earn higher incomes and adjustments to future events.

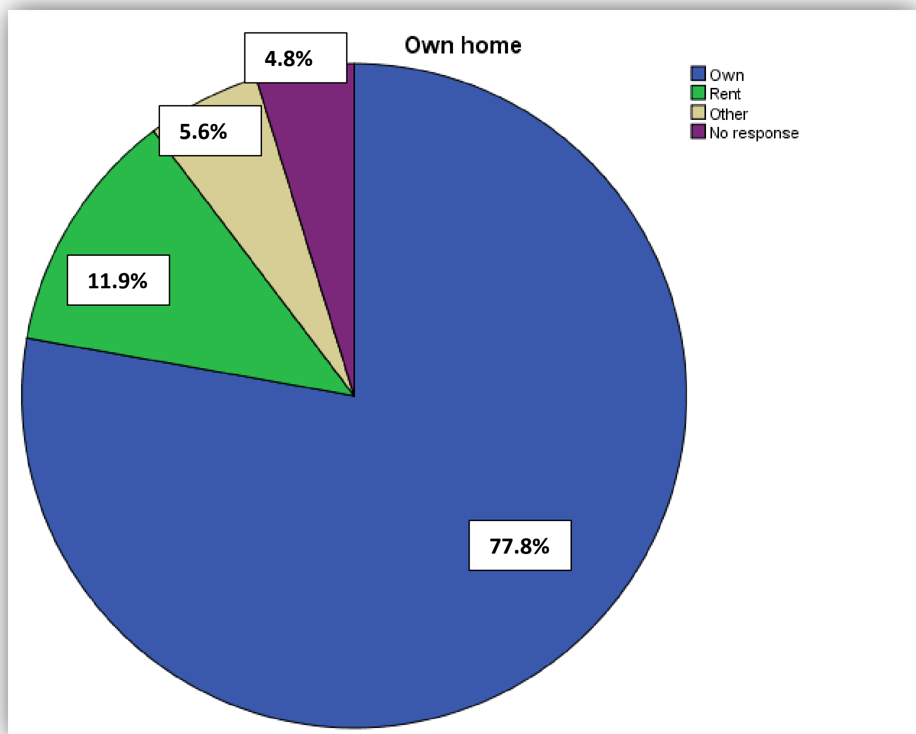

Figure 38. Percentage distribution by home ownership

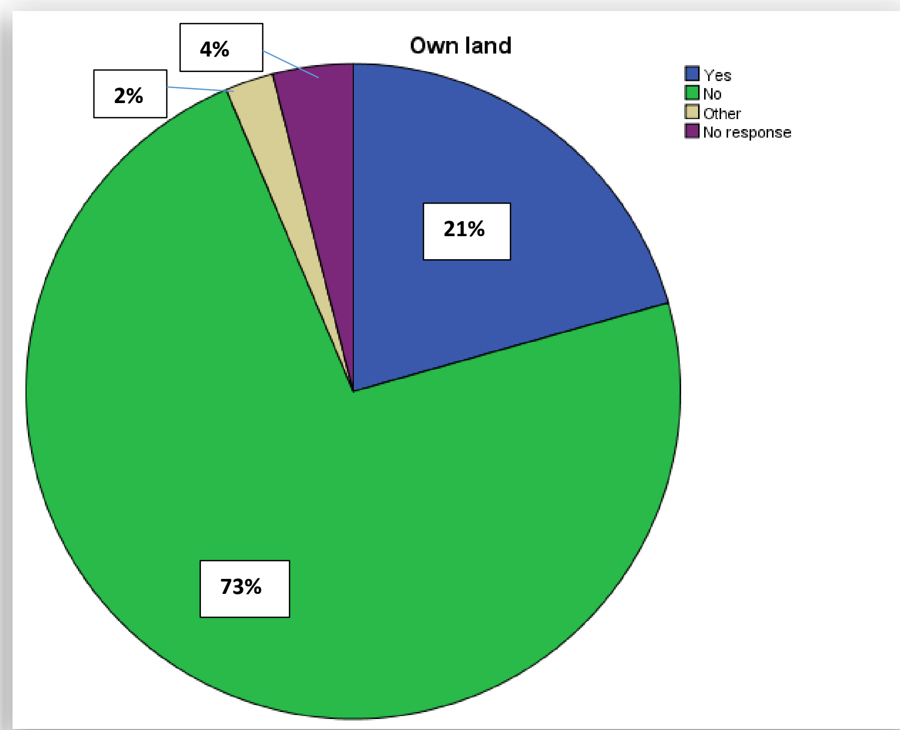

Figure 39. Percentage distribution by land ownership

Approximately 78% of respondents owned their homes, while 21% owned the land on which the house was built (See Figure 38 and Figure 39). Homeowners may tend to employ more risk mitigation techniques to protect their assets compared with those who rent and may not have as much invested. However, in rural communities, there may not be much difference between those who own and those who rent since residents tend to reside in these places for extended periods.

Household Impacts

To assess the effect of extreme events on households, respondents were asked if households experienced negative impacts as a result of an extreme event. Approximately 28% indicated they were negatively impacted, 69% were not impacted and only 3 % were unsure (See Figure 40).

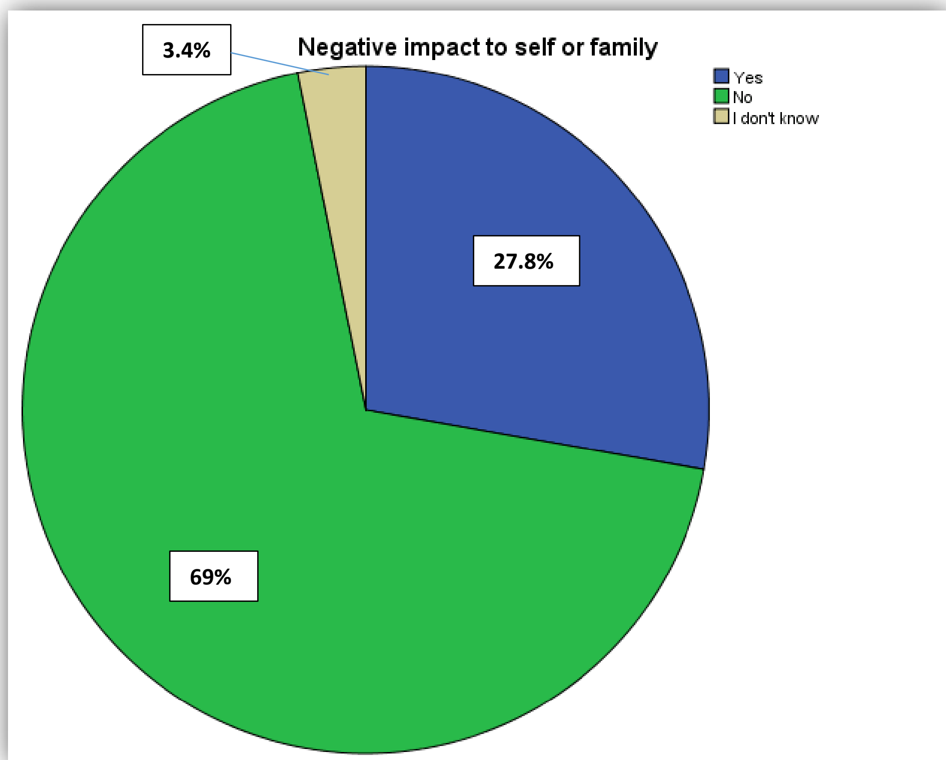

Figure 40. Negative impact to self or family

A contingency table analysis of this question as a dependent variable was produced using the independent variables described above. Of those who were impacted, the majority of impacted households appear to reside in Matelot (50%) compared with 9.5% in Sans Souci and 31.7% in Matura. In Matelot, residents felt that they suffered less than did the village as a whole. While in Sans Souci and Matura, the residents felt that they suffered more personally than the village as whole. The association, although weak (Cramer's V = 0.271; Contingency Coefficient = 0.358) is statistically significant, indicating that households may have different individual and communal experiences with extreme events as a result of the physical location of their communities (See Table 3).

			Village of Residence			Total
			Matelot	Sans Souci	Matura	
Negative impact to self or family	Yes	Count	12	4	19	35
		% within Negative impact to self or family	34.3%	11.4%	54.3%	100.0%
		% within Village of Residence	50.0%	9.5%	31.7%	27.8%
		% of Total	9.5%	3.2%	15.1%	27.8%
	No	Count	12	38	37	87
		% within Negative impact to self or family	13.8%	43.7%	42.5%	100.0%
		% within Village of Residence	50.0%	90.5%	61.7%	69.0%
		% of Total	9.5%	30.2%	29.4%	69.0%
	I don't know	Count	0	0	4	4
		% within Negative impact to self or family	0.0%	0.0%	100.0%	100.0%
		% within Village of Residence	0.0%	0.0%	6.7%	3.2%
		% of Total	0.0%	0.0%	3.2%	3.2%
Total		Count	24	42	60	126
		% within Negative impact to self or family	19.0%	33.3%	47.6%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	19.0%	33.3%	47.6%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.559[a]	4	.001	.001	
Likelihood Ratio	20.888	4	.000	.000	
Fisher's Exact Test	17.489			.000	
Linear-by-Linear Association	1.854[b]	1	.173	.201	.107

Table 3. Cross tabulation analysis of Negative impact to self and family by Village of residence

In terms of type of negative impact (n=88), blocked / lost roads was the most frequently reported type of impact (25%) followed by damage / loss of home (18%) and interrupted water / electricity service (14%). Physical / mental injury / loss of family members and physical / mental injury to self were the least frequently reported type of impact (6%) (See Figure 41). Statistically significant relationships were determined through Fisher's exact test between the top three types of negative impact and the village of residence, monthly household income and years of education. Blocked roads were significant at the p value 0.05 for Education variable. Loss / damage to home was significant at p value 0.05 for Village variable. Lost / interrupted services was significant at the p value 0.01 for Village variable and 0.05 for Monthly household income variable.

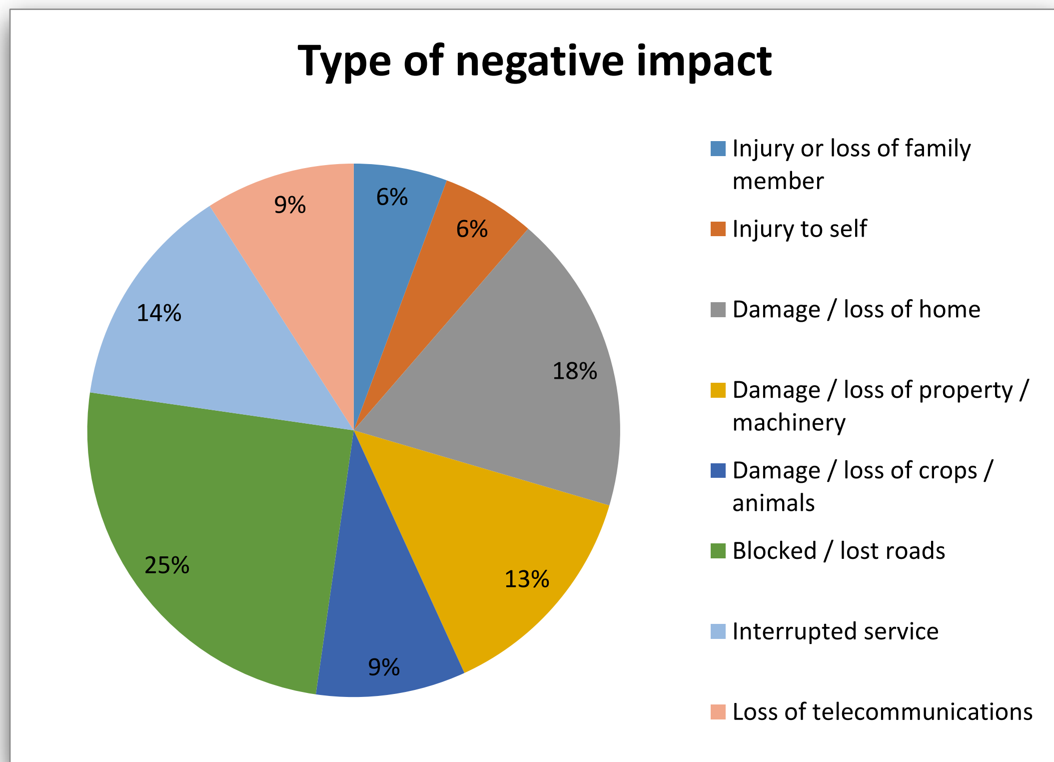

Figure 41. Percentage distribution of type of negative impacts

Of those who were negatively impacted, the majority of respondents indicated that they or their households were moderately affected by the extreme event (56%) while 14.5% of impacted respondents experienced a great deal of harm. Only 5% of respondents indicated they left the region to earn a living as a result of the extreme event (See Figure 42). However, the cross tabulation analysis did not reveal any statistically significant relationships with independent variables.

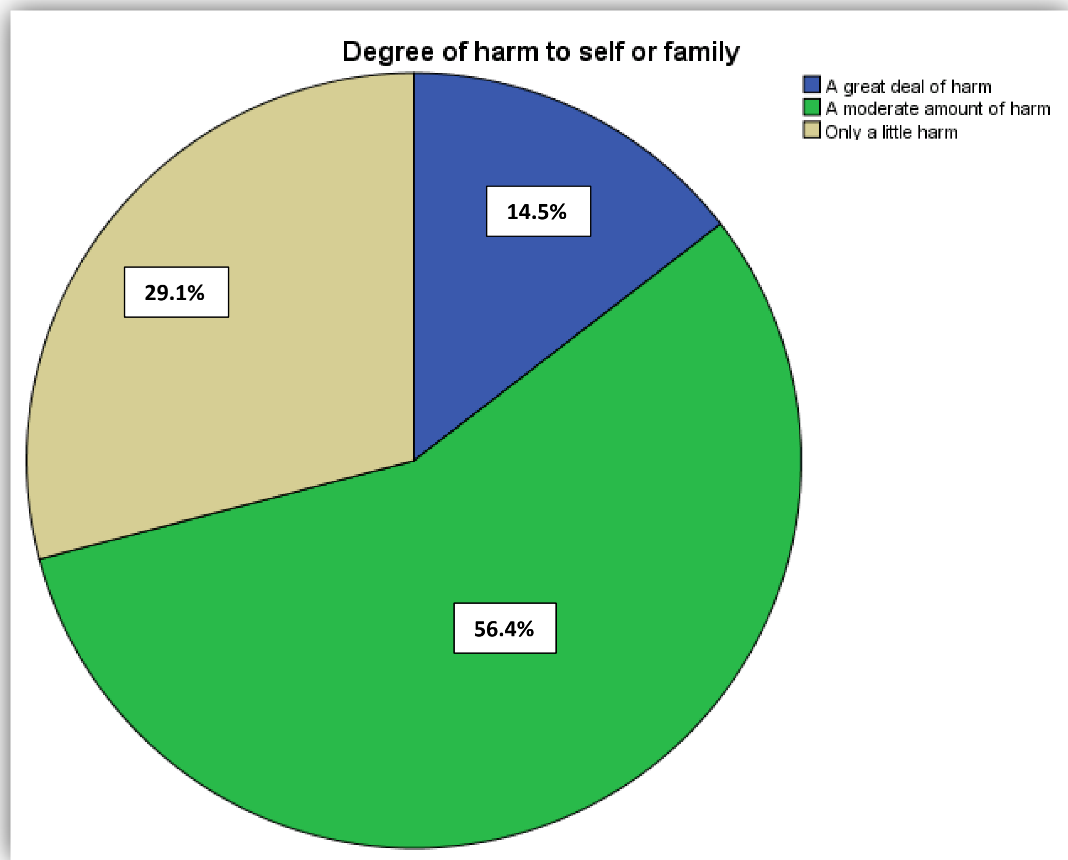

Figure 42. Degree of harm to self or family

Regarding the effect of these events on the ability to earn a living, the survey results indicate that approximately 15% of respondents' reported that their livelihoods were affected, while overwhelming majority of respondents' indicated their ability to earn a living was not affected (approximately 85%) (See Figure 43).

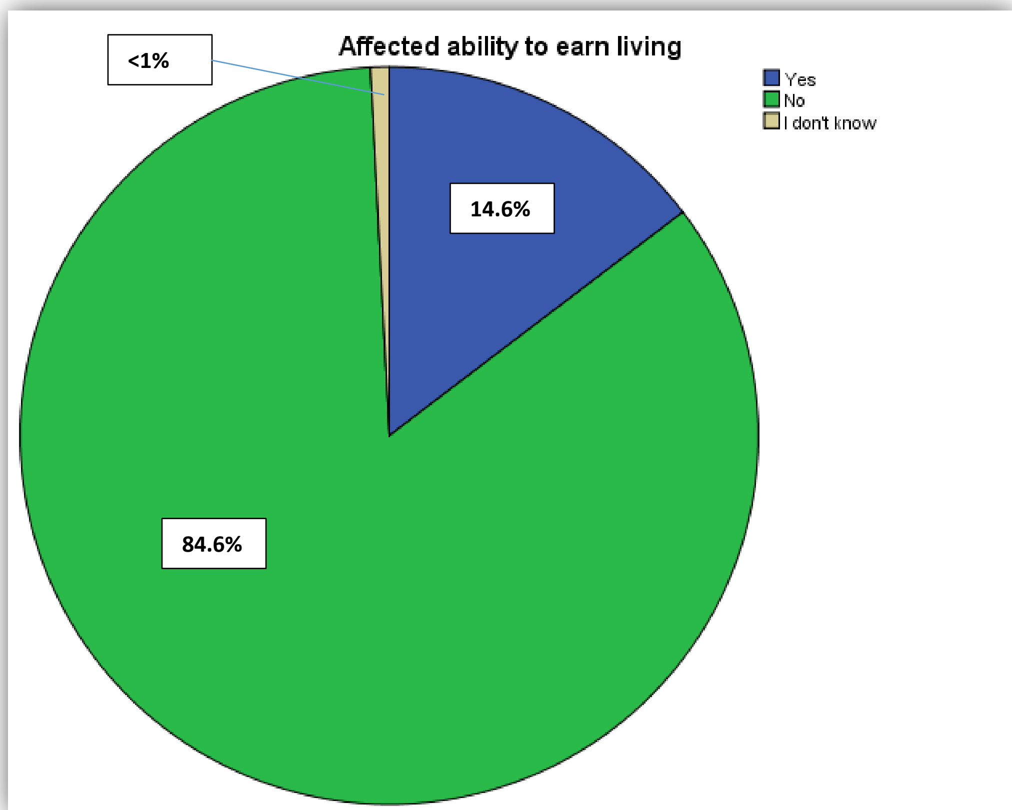

Figure 43. Affected ability to earn living

Of those whose livelihoods were affected, the majority of respondents resided in Matura (approximately 22%) while 18% lived in Matelot and approximately 2% live in Sans Souci (See Table 4). Fisher's test statistics is significant at 99% confidence level (p=0.01), however Cramer's V and Contingency Coefficient (0.197 and 0.268 respectively) indicate the relationship is weak (See Table 4). A statistically significant relationship was also found between monthly household income and whether the respondent's livelihood was affected.

			Village of Residence			
			Matelot	Sans Souci	Matura	Total
Affected ability to earn living	Yes	Count	4	1	13	18
		% within Affected ability to earn living	22.2%	5.6%	72.2%	100.0%
		% within Village of Residence	18.2%	2.4%	22.0%	14.6%
		% of Total	3.3%	0.8%	10.6%	14.6%
	No	Count	18	40	46	104
		% within Affected ability to earn living	17.3%	38.5%	44.2%	100.0%
		% within Village of Residence	81.8%	95.2%	78.0%	84.6%
		% of Total	14.6%	32.5%	37.4%	84.6%
	I don't know	Count	0	1	0	1
		% within Affected ability to earn living	0.0%	100.0%	0.0%	100.0%
		% within Village of Residence	0.0%	2.4%	0.0%	0.8%
		% of Total	0.0%	0.8%	0.0%	0.8%
Total		Count	22	42	59	123
		% within Affected ability to earn living	17.9%	34.1%	48.0%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	17.9%	34.1%	48.0%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.524[a]	4	.049	.029	
Likelihood Ratio	11.769	4	.019	.011	
Fisher's Exact Test	10.649			.010	
Linear-by-Linear Association	1.584[b]	1	.208	.258	.136
N of Valid Cases	123				

Table 4. Cross tabulation analysis of Ability to earn living affected by Village of residence

			Monthly household income		
			$5,000 or less	Over $5,000	Total
Affected ability to earn living	Yes	Count	9	9	18
		% within Affected ability to earn living	50.0%	50.0%	100.0%
		% within Monthly household income	10.6%	26.5%	15.1%
		% of Total	7.6%	7.6%	15.1%
	No	Count	75	25	100
		% within Affected ability to earn living	75.0%	25.0%	100.0%
		% within Monthly household income	88.2%	73.5%	84.0%
		% of Total	63.0%	21.0%	84.0%
	I don't know	Count	1	0	1
		% within Affected ability to earn living	100.0%	0.0%	100.0%
		% within Monthly household income	1.2%	0.0%	0.8%
		% of Total	0.8%	0.0%	0.8%
Total		Count	85	34	119
		% within Affected ability to earn living	71.4%	28.6%	100.0%
		% within Monthly household income	100.0%	100.0%	100.0%
		% of Total	71.4%	28.6%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.075[a]	2	.079	.076	
Likelihood Ratio	4.968	2	.083	.076	
Fisher's Exact Test	4.867			.076	
Linear-by-Linear Association	5.032[b]	1	.025	.031	.026
N of Valid Cases	119				

Table 5. Cross tabulation analysis of Ability to earn living affected by Monthly household income

Of those whose livelihoods were affected, 26.5% of had incomes over $5000 and approximately 11% had incomes below $5000. This was found to be statistically significant at 90% confidence level (p=0.079) however, Cramer's V and Contingency Coefficient are low (0.207) indicating that the relationship is a weak one (See Table 5).

The proportion of those who perceive the probability of future occurrence as unlikely is slightly larger (approximately 56%) than the percentage of those who consider the risk as more likely than not (44%) (See Figure 44).

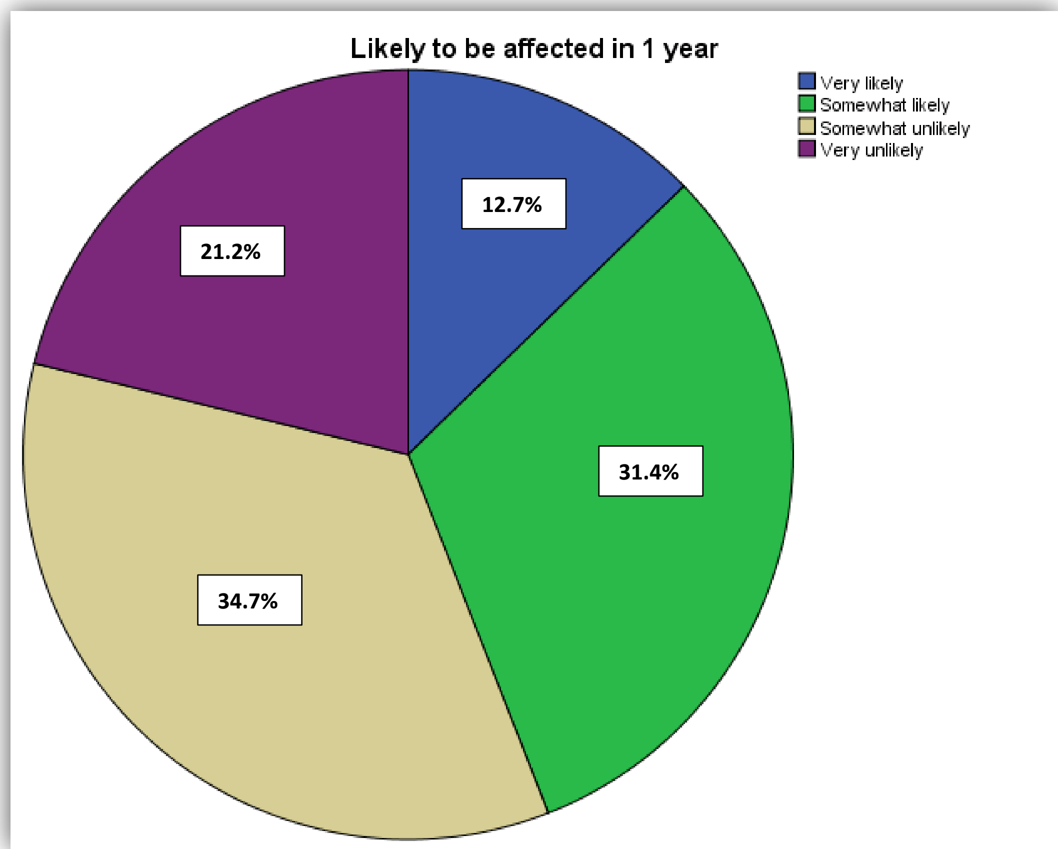

Figure 44. Likelihood of being affected in 1 year

To further assess respondent's risk perceptions, a composite index was created using responses to questions regarding awareness of weather related events or shocks (See Appendix H). The level of awareness index estimated the respondent's perceptions about current and future changes in the weather and the actual or potential impact on his/her self, household and community. Overall, almost half (47.6%) of respondents indicated awareness of these changes, 37.3% were unsure about changes, and 13.5% were not aware of any changes in the weather (See Figure 45).

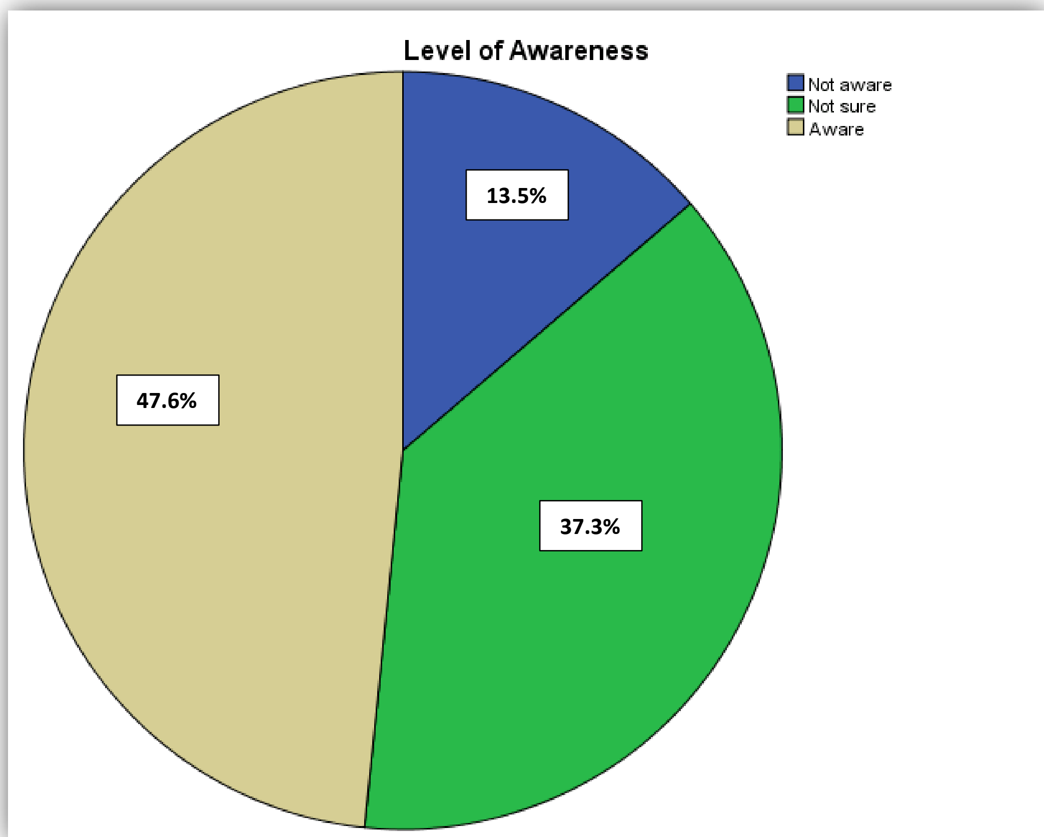

Figure 45. Level of awareness to weather related events / shocks

A contingency table analysis indicates that of the three villages, Sans Souci residents were the most unaware (35.7%) compared with Matelot and Matura residents (4.3% and 1.7% respectively). A majority of respondents in Matelot and Sans Souci were unsure about changes in and impacts of the weather (52.2%) and (40.5%) respectively. Conversely, most respondents from Matura indicated an awareness of change (67.8%), almost three times greater than San

Souci residents (23.8%) and 1.5 times greater than Matelot residents (43.5%). Results reveal there is a moderate relationship (Cramer's V = 0.37) between level of awareness and the village of residence which is statistically significant (p=0.000) (See Table 6).

			Village of Residence			Total
			Matelot	Sans Souci	Matura	
Level of Awareness	Not aware	Count	1	15	1	17
		% within Level of Awareness	5.9%	88.2%	5.9%	100.0%
		% within Village of Residence	4.3%	35.7%	1.7%	13.7%
		% of Total	0.8%	12.1%	0.8%	13.7%
	Not sure	Count	12	17	18	47
		% within Level of Awareness	25.5%	36.2%	38.3%	100.0%
		% within Village of Residence	52.2%	40.5%	30.5%	37.9%
		% of Total	9.7%	13.7%	14.5%	37.9%
	Aware	Count	10	10	40	60
		% within Level of Awareness	16.7%	16.7%	66.7%	100.0%
		% within Village of Residence	43.5%	23.8%	67.8%	48.4%
		% of Total	8.1%	8.1%	32.3%	48.4%
Total		Count	23	42	59	124
		% within Level of Awareness	18.5%	33.9%	47.6%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	18.5%	33.9%	47.6%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	34.628[a]	4	.000	.000	
Likelihood Ratio	34.995	4	.000	.000	
Fisher's Exact Test	32.779			.000	
Linear-by-Linear Association	8.495[b]	1	.004	.003	.002
N of Valid Cases	124				

Table 6. Cross tabulation analysis of Level of awareness and Village of residence

			Years living in Region		Total
			Up to 20 years	More than 20 years	
Level of Awareness	Not aware	Count	1	16	17
		% within Level of Awareness	5.9%	94.1%	100.0%
		% within Years living in Region	2.9%	18.2%	13.8%
		% of Total	0.8%	13.0%	13.8%
	Not sure	Count	12	35	47
		% within Level of Awareness	25.5%	74.5%	100.0%
		% within Years living in Region	34.3%	39.8%	38.2%
		% of Total	9.8%	28.5%	38.2%
	Aware	Count	22	37	59
		% within Level of Awareness	37.3%	62.7%	100.0%
		% within Years living in Region	62.9%	42.0%	48.0%
		% of Total	17.9%	30.1%	48.0%
Total		Count	35	88	123
		% within Level of Awareness	28.5%	71.5%	100.0%
		% within Years living in Region	100.0%	100.0%	100.0%
		% of Total	28.5%	71.5%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.713[a]	2	.035	.034	
Likelihood Ratio	7.968	2	.019	.021	
Fisher's Exact Test	6.918			.029	
Linear-by-Linear Association	6.470[b]	1	.011	.011	.007
N of Valid Cases	123				

Table 7. Cross tabulation analysis of Level of awareness and Years living in region

Those who lived in the region more than 20 years were less aware of the changes than those living in the region for less than 20 years (18.2% and 2.9% respectively). The analysis reveals a weak but significant relationship between the time living in the region and the level of awareness (p =0.021; Cramer's V = 0.234) (See Table 7).

A cross-tab analysis reveals that residents with a higher than average (more than $5,000 a month) household income were much more aware of changes in the weather than those with a below average monthly household income (71.4% versus 40%). Of the residents who were not aware of any changes, the percentage of residents with below average salary was 18 times greater than residents with above average monthly household incomes (18% versus 0%). Of the residents who were unsure about the changes, the percentage of residents with below average household income was over 1.5 times greater than the percentage of residents with higher household incomes (41% versus 29%). The analysis reveals a moderate relationship (Cramer's V = 0.324) which is statistically significant (p=0.001) (See Table 8).

			Monthly household income		
			$5,000 or less	Over $5,000	Total
Level of Awareness	Not aware	Count	16	0	16
		% within Level of Awareness	100.0%	0.0%	100.0%
		% within Monthly household income	18.8%	0.0%	13.3%
		% of Total	13.3%	0.0%	13.3%
	Not sure	Count	35	10	45
		% within Level of Awareness	77.8%	22.2%	100.0%
		% within Monthly household income	41.2%	28.6%	37.5%
		% of Total	29.2%	8.3%	37.5%
	Aware	Count	34	25	59
		% within Level of Awareness	57.6%	42.4%	100.0%
		% within Monthly household income	40.0%	71.4%	49.2%
		% of Total	28.3%	20.8%	49.2%
Total		Count	85	35	120
		% within Level of Awareness	70.8%	29.2%	100.0%
		% within Monthly household income	100.0%	100.0%	100.0%
		% of Total	70.8%	29.2%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	12.619[a]	2	.002	.002	
Likelihood Ratio	16.786	2	.000	.000	
Fisher's Exact Test	13.763			.001	
Linear-by-Linear Association	12.502[b]	1	.000	.001	.000
N of Valid Cases	120				

Table 8. Cross tabulation analysis of Level of awareness by Monthly household income

Household responses to extreme events

In terms of households' ability to cope with the impact of extreme events, a composite index was developed using responses to questions regarding the household's ability to cope when an extreme event occurs (See Appendix H). A majority of respondents indicated that they were able to cope with the impact of the event (58%), while 39% were somewhat able to cope. A very small percentage (less than 2%) were unable to cope (See Figure 46).

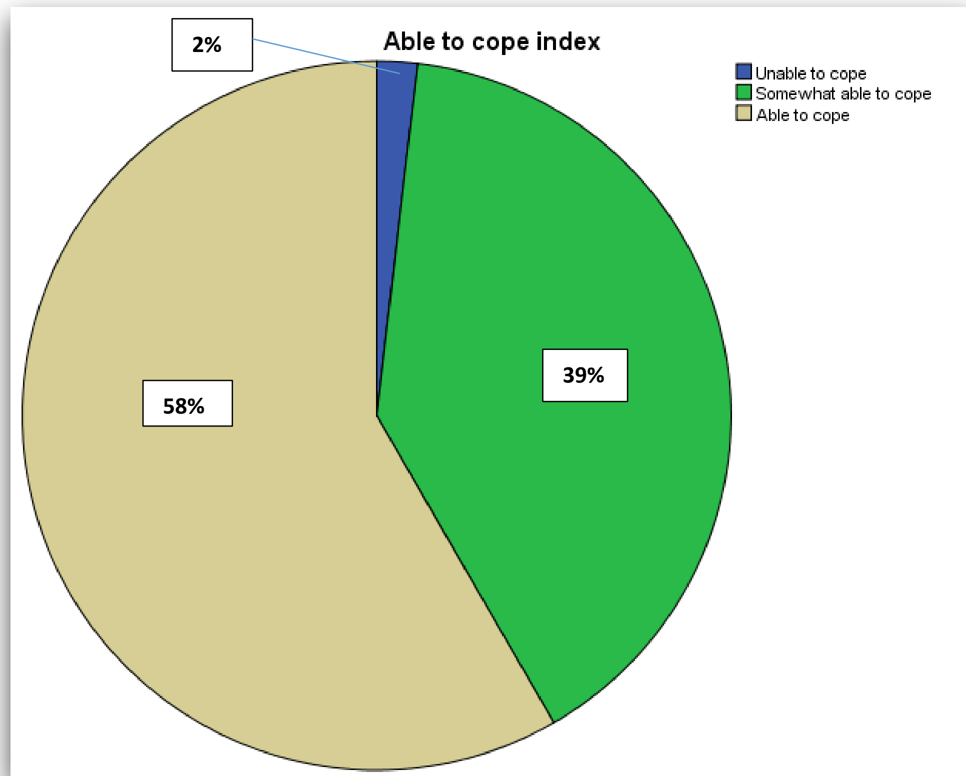

Figure 46. Ability to cope index

			Village of Residence			Total
			Matelot	Sans Souci	Matura	
Able to cope index	Unable to cope	Count	0	0	2	2
		% within Able to cope index	0.0%	0.0%	100.0%	100.0%
		% within Village of Residence	0.0%	0.0%	4.4%	1.9%
		% of Total	0.0%	0.0%	1.9%	1.9%
	Somewhat able to cope	Count	18	1	24	43
		% within Able to cope index	41.9%	2.3%	55.8%	100.0%
		% within Village of Residence	85.7%	2.4%	53.3%	39.8%
		% of Total	16.7%	0.9%	22.2%	39.8%
	Able to cope	Count	3	41	19	63
		% within Able to cope index	4.8%	65.1%	30.2%	100.0%
		% within Village of Residence	14.3%	97.6%	42.2%	58.3%
		% of Total	2.8%	38.0%	17.6%	58.3%
Total		Count	21	42	45	108
		% within Able to cope index	19.4%	38.9%	41.7%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	19.4%	38.9%	41.7%	100.0%

Variations among the different villages were found to be statistically significant at the 0.05 level. Of those who were able to cope, a majority lived in Sans Souci (97.6%) while Matelot residents were more likely to be able to cope somewhat (85.7%). Matura residents were fairly equally distributed between the two categories. The Cramer's V and Contingency Coefficients were high indicating there was a moderate relationship between the two variables (See Table Table 9).

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	50.859[a]	4	.000	.000	
Likelihood Ratio	61.002	4	.000	.000	
Fisher's Exact Test	56.650			.000	
Linear-by-Linear Association	.011[b]	1	.915	1.000	.504
N of Valid Cases	108				

Table 9. Cross tabulation analysis of Ability to cope index and Village of residence

			Degree of harm to self or family			
			A great deal of harm	A moderate amount of harm	Only a little harm	Total
Able to cope index	Unable to cope	Count	2	0	0	2
		% within Able to cope index	100.0%	0.0%	0.0%	100.0%
		% within Degree of harm to self or family	25.0%	0.0%	0.0%	4.8%
		% of Total	4.8%	0.0%	0.0%	4.8%
	Somewhat able to cope	Count	4	12	12	28
		% within Able to cope index	14.3%	42.9%	42.9%	100.0%
		% within Degree of harm to self or family	50.0%	63.2%	80.0%	66.7%
		% of Total	9.5%	28.6%	28.6%	66.7%
	Able to cope	Count	2	7	3	12
		% within Able to cope index	16.7%	58.3%	25.0%	100.0%
		% within Degree of harm to self or family	25.0%	36.8%	20.0%	28.6%
		% of Total	4.8%	16.7%	7.1%	28.6%
Total		Count	8	19	15	42
		% within Able to cope index	19.0%	45.2%	35.7%	100.0%
		% within Degree of harm to self or family	100.0%	100.0%	100.0%	100.0%
		% of Total	19.0%	45.2%	35.7%	100.0%

Table 10. Cross tabulation analysis of Coping ability index and Degree of harm experienced

A cross-tab analysis of coping ability with degree of harm experienced reveals that of those who were most harmed, 25% were unable to cope, 50% were somewhat able to cope and 25% were able to cope (See Table 10). However, this association was not found to be statistically significant (Fisher's Exact Test = 0.106).

The most prominent coping strategy households employed after an extreme event was to make contact with family/friends/neighbors (56%), while surprisingly the second a large majority of respondents indicated that they took no action in the face of an event.

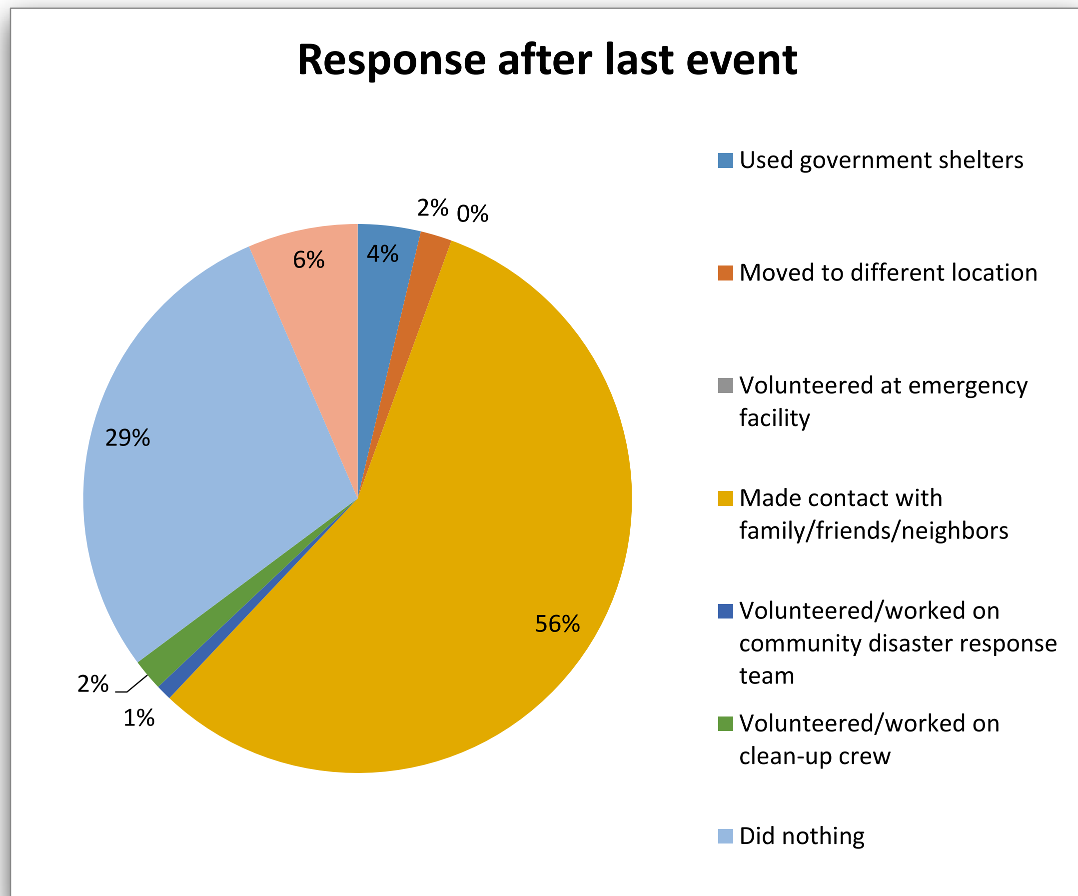

Figure 47. Responses after extreme event

Variations among the different villages were found to be statistically significant at the 0.05 level. Of those who contacted friends/families/neighbors, a majority lived in Sans Souci (90%) while Matelot and Matura residents were less likely to contact others (70 and 73% respectively). The Cramer's V and Contingency Coefficients were high indicating there was a moderate relationship between the two variables (See Table 11).

Variations among the time spent living in the region were found to be statistically significant at the 0.05 level. Of those who contacted friends/families/neighbors, a majority lived in the region more than 20 years (54.5%) while those who lived in the region less than 20 years were less likely to contact others (67.6%). The Cramer's V and Contingency Coefficients were low indicating there was a weak relationship between the two variables (See Table 12).

			Village of Residence			
			Matelot	Sans Souci	Matura	Total
Responded to last event by making contact with others	No	Count	17	4	44	65
		% within Responded to last event by making contact with others	26.2%	6.2%	67.7%	100.0%
		% within Village of Residence	70.8%	9.5%	73.3%	51.6%
		% of Total	13.5%	3.2%	34.9%	51.6%
	Yes	Count	7	38	16	61
		% within Responded to last event by making contact with others	11.5%	62.3%	26.2%	100.0%
		% within Village of Residence	29.2%	90.5%	26.7%	48.4%
		% of Total	5.6%	30.2%	12.7%	48.4%
Total		Count	24	42	60	126
		% within Responded to last event by making contact with others	19.0%	33.3%	47.6%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	19.0%	33.3%	47.6%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	44.675[a]	2	.000	.000		
Likelihood Ratio	49.564	2	.000	.000		
Fisher's Exact Test	48.142			.000		
Linear-by-Linear Association	3.828[b]	1	.050	.063	.033	.014
N of Valid Cases	126					

Table 11. Cross tabulation analysis of Post-event response and Village of residence

		Years living in Region		Total
		Up to 20 years	More than 20 years	
Responded to last event by making contact with others	Count	25	40	65
	% within Responded to last event by making contact with others	38.5%	61.5%	100.0%
	% within Years living in Region	67.6%	45.5%	52.0%
	% of Total	20.0%	32.0%	52.0%
	Count	12	48	60
	% within Responded to last event by making contact with others	20.0%	80.0%	100.0%
	% within Years living in Region	32.4%	54.5%	48.0%
	% of Total	9.6%	38.4%	48.0%
Total	Count	37	88	125
	% within Responded to last event by making contact with others	29.6%	70.4%	100.0%
	% within Years living in Region	100.0%	100.0%	100.0%
	% of Total	29.6%	70.4%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	5.103[a]	1	.024	.031	.019	
Continuity Correction[b]	4.256	1	.039			
Likelihood Ratio	5.195	1	.023	.031	.019	
Fisher's Exact Test				.031	.019	
Linear-by-Linear Association	5.062[c]	1	.024	.031	.019	.012
N of Valid Cases	125					

Table 12. Cross tabulation of Response by contacting other by Years living in region

The trend on coping strategies continues along this theme of risk acceptance, where the most prevalent recovery response was to stay in place and rebuild / reinforce existing structures on the house (49%). Changes to income and food sources was the second but much less prevalent strategy employed (15%) (See Figure 48).

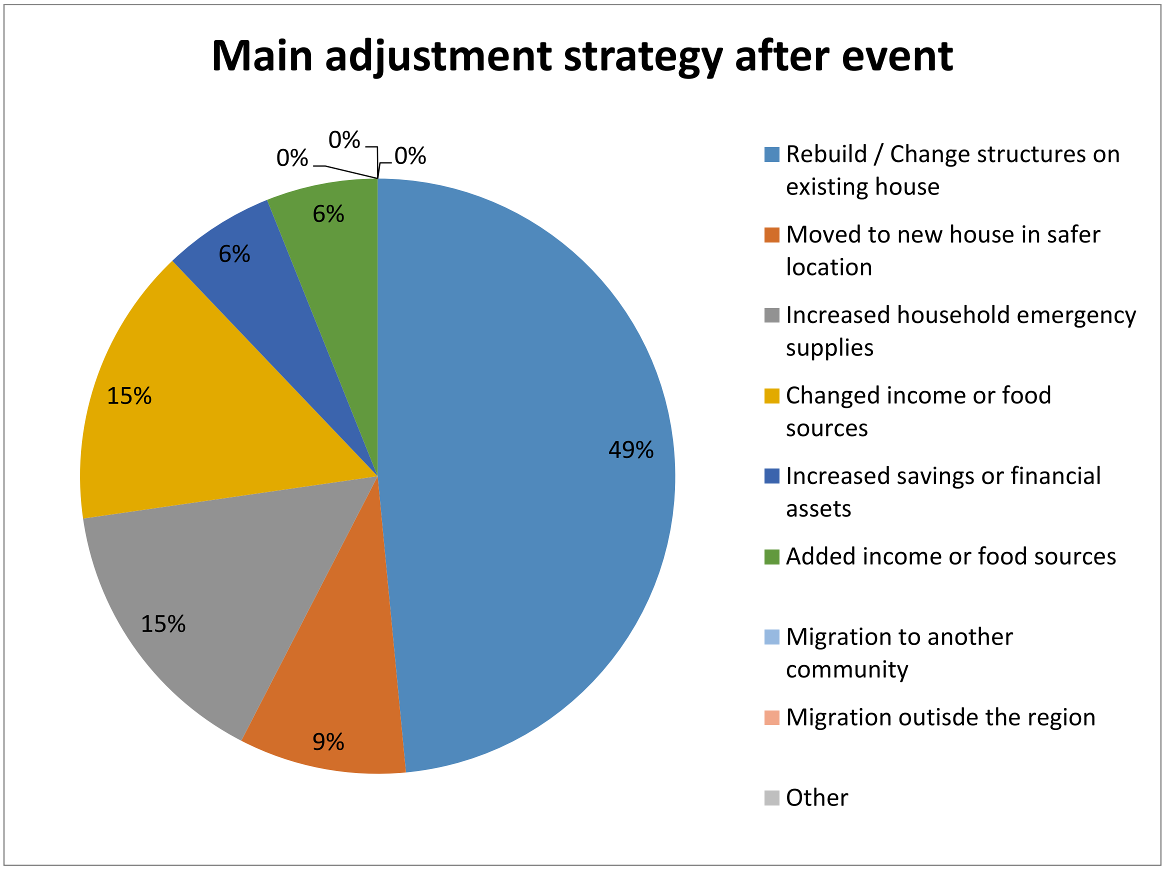

Figure 48. Post-event adjustment strategy

			Village of Residence			Total
			Matelot	Sans Souci	Matura	
Coping strategy: Rebuilt/changed structures on house	No	Count	21	42	47	110
		% within Coping strategy: Rebuilt/changed structures on house	19.1%	38.2%	42.7%	100.0%
		% within Village of Residence	87.5%	100.0%	78.3%	87.3%
		% of Total	16.7%	33.3%	37.3%	87.3%
	Yes	Count	3	0	13	16
		% within Coping strategy: Rebuilt/changed structures on house	18.8%	0.0%	81.3%	100.0%
		% within Village of Residence	12.5%	0.0%	21.7%	12.7%
		% of Total	2.4%	0.0%	10.3%	12.7%
Total		Count	24	42	60	126
		% within Coping strategy: Rebuilt/changed structures on house	19.0%	33.3%	47.6%	100.0%
		% within Village of Residence	100.0%	100.0%	100.0%	100.0%
		% of Total	19.0%	33.3%	47.6%	100.0%

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	10.463[a]	2	.005	.005		
Likelihood Ratio	15.111	2	.001	.001		
Fisher's Exact Test	12.206			.002		
Linear-by-Linear Association	3.578[b]	1	.059	.080	.039	.023
N of Valid Cases	126					

Table 13. Cross tabulation analysis of post-event Adjustment strategy and Village of residence

Variations among the different villages were found to be statistically significant at the 0.01 level. Of those who rebuilt their homes, none lived in Sans Souci (0%) while Matura residents (although still a small percentage – 17%) were the largest group to employ the strategy. The Cramer's V and Contingency Coefficients were low indicating there was a weak relationship between the two variables (See Table 13).

Analysis

The survey analysis generated some expected and unexpected findings about household awareness, impacts and responses to extreme events. In spite of spatial and physical evidence of repeated events occurring in the region, a significant portion of the survey respondents indicated they were not negatively impacted by extreme events (69%) and 58% responded that were able to cope with impacts. For most households who were negatively impacted, the degree of harm was categorized as moderate and only 25% of impacted residents were unable to cope. Such findings suggest that there may be an inherent level of resilience existing within these households.

The survey did show that loss / injury to self/ other household members was least frequent outcome experienced. . In addition, only 15% of respondents indicated that their ability to pursue their livelihoods were affected. These households may not be experiencing significant tangible losses of life or assets related to extreme events at this time. A potential explanation could be related to the type of hazard event experienced and the associated spatial scale of impact. When an event such as a flood or a landslide occurs, it is generally confined to a specific locality/affects specific households and is not widespread enough for all households in a given community to incur significant loses of income, assets or suffer grave injuries or death. Unlike a drought or hurricane whose effects can cross districts and boundaries with similar intensity, the footprint of a landslide or flood is generally contained and defined. Consequently, an event that may be considered extreme in intensity and severity for one household, may not translate to be extreme for another or for the community in aggregate. However, should extreme rainfall events such as the 2011 event which claimed the home and life of the Sans Souci man and triggered several landslides throughout the region become more frequent with climate change, there may be a shift in the proportion of households who directly suffer losses and are negatively impacted.

There is also a temporal dimension in the nature of the impact which may affect how households categorize their direct and indirect losses. Even though blocked roads can cut off entire communities and was identified as the most significant impact, the outcomes of such an event may be regarded as a temporary inconvenience, rather than a long-term problem. A blocked road, once cleared would not lead to long-term losses in income or the ability to pursue a livelihood, compared with losing a home or a family member. The low proportion of respondents who were unable to pursue livelihood activities because of blocked roads may also indicate that labor mobility within the region is confined, where residents tend to stay within the community in which they reside to pursue their livelihoods. Therefore, blockage of the road way between communities would not necessarily lead to drastic losses in wages or affect the ability to work. This suggestion receives some support from the survey results, where Matelot residents experienced negative impacts compared with the other communities. Since Matelot-St. Helena is at the end of the main road, a landslide which isolates these communities can be more burdensome as access to resources, foods and emergency services would be limited to what exists within the community itself. However, indirect losses of time and access to education should also be incorporated when evaluating the overall magnitude of impact on the household.

Some expected findings were that statistically significant associations would exist when assessing impacts and coping strategies with variables such as Village of residence and Monthly household income. These are two important characteristics which can influence the way a household experiences a particular hazard as well as the ability to access resources and savings to buffer against the shocks and recover. In terms of livelihood impacts, more Matura residents found their livelihoods to be impacted, even though the Matura community appears to have more diversification of livelihood options. More households with higher incomes also indicated that their livelihoods were affected compared with poorer households were impacted. The typical assumption would be that poorer households, with limited resources, would be more susceptible to impact. However in this case of the survey results, the opposite relationship exists and the reasons why remains speculative. Perhaps lower income households are already diversified in terms of livelihoods which can be pursued at specific times during the way.

In terms of awareness level, the results indicated that Matura residents were the most aware of changes occurring with the weather/climate. While Sans Souci residents were least aware. Yet at the same time, Sans Souci residents regarded themselves as more able to cope and cooperate with other villages and also reached out to social networks more than residents in other villages. The question of whether Sans Souci is feeling the least impacts may be related to their ability to absorb shocks through kinship networks, so that consequences of the extreme are not as disruptive compared with Matelot or Matura. The Church is an especially important institution in these communities and the Sans Souci community has a large proportion of residents belonging to the same Seventh-Day Adventist faith. This religious bonds within the community perhaps creates networks which may be the reason why Sans Souci residents engage and lean on family/friends etc. beyond typical norms.

Permanent migration or relocation out of the area did not appear to be a favored adjustment strategy by any of the villages while rebuilding was the most preferred strategy. Even if residents temporarily left the area to stay with family or friends outside the region, the chances are that they will return to the region to rebuild and recover are better. This has significant implications for adaptation planning measures which may consider retreat and relocation of these settlements as a viable option.

Other variables which surprisingly did not reveal any statistically significant results were Land tenure, Gender and Years in region. The effects of differences in these types of characteristics may be more nuanced and may require a larger sample size to unpack the relationships and associations.

Chapter 9 . Pathways to a climate resilient Turtle Region

Climate extremes erode the steps made towards reducing poverty and achieving social justice as it directly threatens the livelihood security of vulnerable and margainalized. Although they are responsible for a small percentage of greenhouse gas emissions, the adverse effects of a changing climate will likely fall disproportionately on small island populations and further exacerbate pressures on their fragile ecosystems and the livelihoods which depend on them. The risks associated with a changing climate call for a broad spectrum of policy responses and strategies at the local, regional, national and global levels. The challenge of adaptation planning at the local level is that there is a lack of scaled information on impacts and linking local knowledge with climate issues and appropriate strategies to adapt. In the Caribbean, efforts to adapt are expanding at the regional and national scales, however little is known about how local communities are affected by, respond to and plan for adaptation to climate variability and weather extremes.

This study sought to highlight the socio-spatial impacts of extreme events and the associated responses by households to cope with these events. It employed a local lens to give a voice to those who have been impacted by extreme events. The reverberations of environmental shocks are acutely felt at the household level and can persist long after the initial event occurred. Living in region and dealing with these hazards on a daily basis can generate novel adaptations and behavioral adjustments which an outsider may not contemplate. The assessment revealed three primary hazards – landslides, flooding and coastal erosion - which affect the region collectively however there are distinguishable patterns of exposure and impact mostly affected by the location of the village. For Matelot, the vulnerability is realized and reproduced through repeated landslides which cut the community off from the rest of the region. In Sans Souci, the great risk comes from the low lying location and proximity to the ocean, however the most significant impacts have realized as loss of property and life from landslides. In Matura, flooding is the most significant risk which can have immediate and dramatic impacts on agricultural livelihoods.

Contacting others and rebuilding were the primary coping strategies employed by households, while migration does not appear to be a prevalent strategy. A large portion of households, although seemingly able to cope, make no adjustments in preparation for future events or shocks indicating perhaps that repeated experiences and familiarity with a particular risk over time translates to a normalization and acceptance of the risk. Regardless of whether these conditions makes households the Turtle Region resilient to existing risks or unprepared to face future risks, early intervention of low-cost, high impact anticipatory policy initiatives to facilitate preparedness and adaptation will enable households to persist and resist in the face of changing climatic conditions.

Based on the data collected from this study, several recommendations at the regional, community and household scales are made to develop pathways towards building a more climate resilient region:

Prioritize public infrastructure development and maintenance

The Toco/Paria main is the main arterial through the region and the nexus of much of the exposure to hazard impacts throughout the region since settlements tend to form in linear form along the road way. Significant improvements in the quality of paving, reinforcement and retaining walls are needed along the entire stretch, however a staged approach to identifying hotspots of high, medium and low priority areas can direct rehabilitation efforts and appropriated funding to the most-at risk areas first using validated engineering and construction methods and materials.

Construct mitigation structures – Hard vs. Soft remedies

The North-North East dynamic and exposed to the action of waves, wind and surges and the assets on the coast appear fixed and growing in value. In order to protect homes, fishing facilities, and businesses structural mitigation measures can be considered to reduce the action of the ocean on the coast. Breakwaters or extended sea walls can slow down the waves and limit sea encroachment. However, these measures are costly and ocean have negative and unintended impacts on the ocean and beach dynamics. This is especially concerning given the beaches in this region support turtle nesting activities. Any proposal to construct a hard structure must be accompanied by a through environmental impact assessment which pays particular attention to the impact the construction and presence of the structure can have on the Turtle populations and other beach and marine habitats (e.g. coral reefs).

Soft mitigation strategies may be better situated for this locality because they are lower cost and provide environmental co-benefits such as reforestation and ecosystem rehabilitation of tree lines and wetlands which can serve as buffers to the impacts of flooding, wave erosion and storm surges. Since there is very limited data on changes to the coastline, the community-based turtle monitoring activities can also incorporate beach profile data collection which can be utilized to monitor changes in the coastal zone and the assess the effect of these mitigation structures.

Enforce land use setbacks and controls

Enforcement of land controls are noticeably absent in the region which may provide opportunities to employ community-based land use strategies and collective ownership co-operatives to manage future land development and rebuilding efforts. Areas which have been degraded by agriculture, informal settlements or quarrying activities can be adopted by the community land cooperative who would oversee its rehabilitation. Such a cooperative would work in tandem with programs such as the National Watershed Restoration program to identify affected areas, pool resources and ensure long-term monitoring and protection.

The reality is that these land use patterns are entrenched and existing community protective infrastructure is deteriorating. A greater presence of the local planning agency to develop and enforce set backs on new development projects as well as an action plan in conjunction with the community cooperatives to address at risk properties.

Promote household education and awareness

Building local awareness of the threats posed by a changing climate and extreme weather events can help households adjust their behaviors to anticipate and prepare for future events. Within the Turtle Region, there already exists an established infrastructure for community based organizations to develop awareness programs and disseminate to households in their respective communities. A region and community specific informational program which highlights the risks and options to prepare for future events can be developed and tailored for dissemination in the institutions which encourage assembly and information exchange such as schools, churches, Village councils and community-based organizations. This initiative can take different forms of media – documentary showings, art displays, brochures, library readings, consultation workshops – and would be the first step towards generating a culture of risk awareness and preparedness within households.

Develop sectoral micro-insurance program

Although a majority of respondents indicated that their livelihoods were not impacted by extreme events, providing micro-insurance mechanisms which can serve as a financial safety net in the event an extreme event disrupts the ability of households to pursue their livelihoods. These protections can come in the form of a savings pool where sectoral co-operatives can pay into the pot and should an event occur payouts are made to participants in the program. The cost and risk burden could be shared and subsidized by the national government in order to keep premiums affordable while sustaining a viable fund to facilitate payouts to recover materials, equipment or supplement incomes due to business interruptions.

Develop community-based emergency response teams

The communities in the Turtle Region should have the ability to respond in a timely manner in the event of a disaster or emergency. Since many instances the region is inaccessible due to flooding or landslides, having response teams within the region can reduce the time lag between the impact and response. Equipment such as a back-hoe and emergency supplies can also be stored in established safe zones or shelters so that they can be accessed faster than waiting for supplies to arrive from outside of the region.

Promote institutional co-operation

In the Turtle Region existing forms of local governance through a strong NGOS partnership network can enable planning and visioning efforts to begin from the bottom-up. The Turtle conservation and protection program provides a vehicle for community engagement and provision of alternative livelihoods in way that builds social capital. The environmental protection and livelihood development NGO network can also be expanded to addressing the preparation of households and promotion of effective resistance and adjustment strategies. Although, there may be a natural overlap with their primary mandate, these NGOs may not have the adequate skills sets or level of training to engage in this arena of social capital development. These NGOs would serve as gatekeepers and advocates for the region as they work to partner with local and national governments to implement projects aimed to build resilience.

The nationally administered Green Fund is a source of funding available to non-profit organizations to fund projects related to protecting the environment and promoting sustainable livelihoods. However, there are administrative barriers which make accessing the funding difficult for organizations with limited capacities. The national government should consider reducing barriers for the application process for organizations whose technical and human resource capacities are limited.

This research is a first step towards understanding the nature of risk and the pathways towards resilience to extreme events that have the potential to be exacerbated by climate change in the Turtle Region of Trinidad in the Caribbean. Future research is needed on other communities within the Turtle Region in order to develop a complete risk profile for the region. An inventory of at-risk zones, zones of impact and zones of safety can provide NGOs with vital spatial data that can be used to inform remedial measures. Assessing the institutional processes and challenges to implementing effective climate adaptation programs in the Region is another avenue of research that will prove useful for evaluating the capacity and programming needs of the institutions working in the Region. The reality of a changing climate is upon us and the data from this research may be used to make comparisons to other SIDS to identify similarities, differences and trends in the ways populations are experiencing climate change and extreme events. Quantitative indicators of resilience can be developed and incorporated with climate risk projections on future extreme events and sea level rise to estimate the potential economic and ecological impact on households as well as the natural resources which support the tourism, fishing and agricultural livelihoods.

Appendix A: Secondary Data Schedule

Environmental Data Document	Date	Author	Content
Forestry Division Annual Data Report	2008-2013		Fire impact
Certificates of Environmental Clearance: Matura	2002-2012		Schedule of CECs
Coastal Protection Works at L'Anse De Four	2009	Haskoning Engineering	Maps and engineering report
Further information for CEC: Coastal Rock Revetments at San Souci Bay	2009	Environmental Management Authority	Maps and engineering report
Application for CEC: Paria Main Road, Grande Riviere	2008	Environmental Management Authority	Map and letter
Meteorological Data	1725-2014	Trinidad & Tobago Meteorological Office	Cyclones Flood events Max and min temps Rainfall
Trinidad Historical Flood Database - Matura to Matelot Region	1993-2010	Water Resources Agency	Flood events Severity Rainfall
Monthly River Flow	1984-2008	Water Resources Agency	Stream flow events
Rainfall	1990-2014	Water Resources Agency	Maximum monthly rainfall Minimum monthly rainfall Average monthly rainfall
2013 Marine Turtle Project Report	2013	Forestry Division	Revenue Turtle data Sector
2010-2011 Report	2010-2011	National Reforestation & Watershed Protection	Reforestation activities
Forest data	2014	National Reforestation & Watershed Protection	Reforestation activities
Matura to Matelot impact data	2010-2013	Disaster Management Unit	Impact events
Flood analysis	2006-2013	ATTIC	Insurance claims from floods

Appendix B: Interview Participant Agency Affiliation

Agency
Caribbean Natural Resources Institute, Trinidad & Tobago
Inter-American Development Bank
University of the West Indies, St. Augustine Campus, Trinidad & Tobago
Trinidad & Tobago Office of Disaster Preparedness and Management
Trinidad & Tobago Environmental Management Authority
Trinidad & Tobago Red Cross/Red Crescent Society
United Nations Development Program, Trinidad & Tobago
Trinidad & Tobago Green Fund
Trinidad & Tobago Ministry of Environment
Trinidad & Tobago Ministry of Works & Infrastructure
Trinidad & Tobago Ministry of Planning – Economic Development Unit
Trinidad & Tobago Ministry of Planning – Town and Country Planning Division
Trinidad & Tobago Ministry of Tourism
Trinidad & Tobago Ministry of Agriculture and Fisheries – Sangre Grande Region
Trinidad & Tobago Forestry Division
Trinidad & Tobago Land Settlement Agency
Trinidad & Tobago Ministry of the People
Trinidad & Tobago Institute of Marine Affairs
Sangre Grande Regional Corporation
Toco Foundation
Turtle Village Trust
Nature Seekers
Grande Riviere Tourism Development Corporation
Sans Souci Nature Tourism and Wildlife Development Organization
Matelot King Fisherman’s Group
Dorca’s Women’s Group

Appendix C: Interview Protocol

Introduction

Thank you for taking the time to speak with me. My name is Tisha Holmes and I am a PhD Candidate from the Urban and Regional Planning Department at the University of California, Los Angeles (UCLA). You were selected as an interview participant in this study because you were identified as a key stakeholder in the communities under investigation in the study. I would like you to share your experience, insights and expertise through this interview. Your participation is voluntary and you can withdraw at any time

The purpose of the research is to examine the impacts of climate-related hazards, extremes and disasters in the communities of Sans Souci, Matura and Matelot in the island of Trinidad and the potentials of building resilience in the region.

This interview will be recorded. Any information that is obtained in connection with this study and that can identify you will remain confidential. It will be disclosed only with your permission or as required by law.

Questions

- What do you think are the most significant risks faced by these communities?
  →Could face in the future?
- What happened during the most recent event?
- What internal and external factors do you believe affect the community's vulnerabilities? coping / adaptive capacities?
- Which are the critical sectors/livelihoods? How are they protected?
- What have been the impacts on livelihoods in the short term? the long term?
- Where is the critical infrastructure? What is at risk? How are they protected?
- What are the relief and response mechanisms in the event of an event?
- What preparedness/mitigation/coping/recovery strategies have evolved as a result of formal interventions/projects?
  →Evolved independently of interventions/projects?
- What provisions are made for the most vulnerable community members?
- In what ways have/can these communities build resilience to climate hazards?
  →What are efforts can be made at the individual, household, community and national scales?
- →What are the most feasible options that can be implemented over the short term? Long term?

Appendix D: Site Assessment Indicators

Category	Indicators/Observation prompts
Geographic context	- What is the site's elevation? - Nearby rivers/streams? - Relative distance from the coast?
Hazard potential	- Are sea level changes recognizable? - Where is erosion occurring? - Is there evidence of frequent flooding? - Is there evidence of frequent landslides? - Is there evidence of other natural / human generated pressures?
Biophysical exposures	- What and where are the critical species/ habitats / ecosystems? - What ecosystem services are at risk? - What and where are the critical land uses? - What and where is the critical infrastructure located? - What and where are housing structures? - Is there evidence of stress? - Is there evidence of impact?
Asset exposures	- Where are public assets located? - Evidence of loss? - Evidence of sustainable / unsustainable practices?
Mitigation measures	- What protective structures are present? In progress? Planned? - Is there evidence of damage/disrepair/neglect? - What areas still require attention? - How and where are 'soft' measures? - How and where is information communicated? - What features differ between communities?

Appendix E: Focus Group Workshop Protocol

Introduction

The purpose of these workshops was to educate and inform community members about the risks associated with climate change, extreme weather events and disasters. It also sought to gain local knowledge and opinions of ways to build resilience – the ability to absorb, resist and/or recover from - climate hazards within their communities through a series of discussion exercises. The intent was achieve mutual information generation and exchange where both the researcher and the community members simultaneously teach and learn.

Method

A participatory workshop of 5-8 participants were administered by the researcher with the assistance of trained volunteers in each community. The workshops were convened at a designated meeting space during a pre-determined weekend and lasted for approximately one - two hours. Participants were sourced through targeted sampling of community members between the ages of 18 and 65 in each community. Participation in the workshop was voluntary and participants could withdraw at any time. Workshop materials and refreshments were provided by the researcher.

Participants

Each focus group contained 5-8 people. Participants were aware, interested in and/or willing to engage in open discussion about their experiences and experiences of the wider community related to climate change impacts and responses. Participant selection was guided by informed community leaders and will try to capture as many representative voices / sectors of the community including but not limited to:

- Farmer/Agriculturalist/Pastoralist
- Tourism worker
- Fisherfolk
- Hotelier
- Teacher/Principal
- Health/Emergency professional
- Retiree/Elderly
- Village council representative
- Laborer
- Police
- Religious leader
- Business owner/developer
- Differently-abled

Schedule

The focus groups were conducted in the communities of Matura, Sans Souci and Matelot. The following days were available for scheduling based on the availability of participants:

Weekend 1	Sun June 1	
Weekend 2	Fri June 13/Sat June 14	
Weekend 3	Fri June 20/Sun June 22	
Weekend 4	Fri June27/Sat June 28	
Weekend 5	Fri July 4/ Sun July 6	
Weekend 6	Fri July 11/ Sun July 13	
Weekend 7	Fri July 18/Sun July 20	

Discussion Script

Thank you for your participation. The purpose of this workshop is to gather information on the impacts climate hazards have had on your community, your livelihoods and envision the elements for a more resilient region for my research project. The workshop which involves open discussion about your experiences with climate related events, the conditions which you believe increase your risk and strategies taken to respond to these risks and disasters. I will moderate the discussion and we encourage you to openly share, listen and engage with each other in mutual respect. This workshop will be taped and your responses to questions written on flip charts and will be used for further analysis and write-up of results. As outlined in the consent form, I am a PhD student at UCLA and my study is an independent project, not affiliated with any governmental agency or private company. The purpose of this project is primarily academic and I do not provide compensation to participants and make no commitments of financial or technical assistance from other parties. However, I will eventually make the recommendations available to you and wider community. Hopefully our findings will help to inform about the hazards the community faces but also promote dialogue about how we address these problems.

Engagement questions

- What is the best thing about living here?

Exit question

- Is there anything else you would like to say about responses to climate hazards in your community?

Hour 1:

Ranking of the most serious hazards facing the community

- List hazards
- Rank on severity
- Score based on number in agreement
- Final list – seek consensus

Timeline of extreme events

- Month, description, impact

Ranking of the vulnerabilities facing the community

- List vulnerabilities – External and internal
- Rank their importance
- Cause → effect Tree

Hour 2:

Coping and adaptation strategies

- List the strategies employed to deal with hazards – indigenous and scientific
- Rank based on effectiveness/feasibility

Institutional mapping

- List the institutions that play a role in community
- Rank their significance

Visioning resilience

- Most likely scenario
- What are the needs

Survey

The following survey was administered at the end of the workshop.

Please complete this short survey and return to the workshop coordinator. Your responses will be kept private and confidential. Thank you for your participation.

Date:

Hour:

Community: Session:

VARIABLE							
Gender		Male	Female				
Age		18-29 years	30-39 years	40-49 years	50+ years		
Years lived in community		<1 year	1-5 years	6-10 years	11-15 years	16-20 years	20+ years
Marital status		Single	Married	Divorced	Common-Law	Widow	
Race	African/Black	Indian	Asian	White	Mixed		
Occupation							
Highest level of formal education	Some primary	Primary	Some Secondary	Secondary	Some College/ Vocational	College	Graduate school or higher
Rank your knowledge about climate change / environmental issues broadly	None	Little knowledge	Somewhat knowledgeable	Knowledgeable	Very knowledgeable		
Rank your knowledge about emergency preparedness and response	No knowledge	Little knowledge	Somewhat knowledgeable	Knowledgeable	Very knowledgeable		
Rank your involvement in community development and planning activities	Not involved	Little involved	Somewhat involved	Involved	Very involved		

Appendix F: Survey Administration Terms and Conditions

Description	Conduct a household survey on opinions and experiences with climate change, weather extreme events and environmental stress in the Matura communities.
Survey Researcher Team	(1)Tisha Holmes
Survey Collector Team	(1) (2) (3)
Survey Coordinator Team	(1) Esther Vidale (2) Dennis Sammy
Study Area	
Target Number of Respondents	
Target Respondent	Head of household
Term	July 16 – August 7, 2014
Deadline date for survey compilation	August 8, 2014
Pricing	$150 for 6 surveys
Responsibilities of Researcher	Provide survey documents, materials and training to survey collectors
Responsibilities of Collector	Collect community data using survey documents and materials
Responsibilities of Coordinator	Collect completed survey documents and send to research team Organize payment to survey collectors with research team
Payment Terms	Payment date: August 8, 2014 / Prior date if all surveys are completed and compiled
Contact information	

Appendix F: Household Survey

Survey Number:________

Community:________________________

Gender of Respondent:_______________

WEATHER EXTREMES AND DISASTER RESILIENCE SURVEY

Thank you for taking the time to speak with me. My name is <____________> and I am working with a doctoral student from the Urban and Regional Planning Department at the University of California, Los Angeles (UCLA) to complete her research project. You were selected as a participant in this project because you are a community member in <_______________> which is one of the communities under investigation in the study. I would like you to share your experience and knowledge through participation in a survey.

The purpose of this survey is to understand the views of community members regarding climate change and environmental stress and the coping strategies used in the face of severe weather events/disasters. The survey will take approximately 30 minutes to complete. Your responses will remain private and confidential.

Participation in this survey is voluntary and you can choose whether or not you want to take this survey and you may withdraw your consent and discontinue participation at any time. If you have any questions you can contact the student: <____________________________> or at <____________________________>. Thank you for your participation.

Household Information

1a. Are you the head of household? ☐ *Yes* ☐ *No*

1b. If not, what is your role in the household?

____

2. How many people are in your household?

____

3. Please list the age and gender of everyone that lives in your household.		4. How many household members commute to work in a different community?	
AGE	GENDER	NUMBER	NAME OF COMMUNITY

5. Are you or any of your household members:

☐ Have physical conditions that limit their mobility ☐ Have mental conditions that limit their daily lives ☐ Have Special Needs ☐ Pregnant

6a. Do you or any household members suffer from any chronic medical conditions / get certain illnesses often? ☐ *Yes* ☐ *No*

6b. If yes, please describe the medical condition(s)/illness(es) e.g. asthma, heart disease, emphysema, cancer, diarrhea, yellow fever, dengue fever, etc.

____

____

____

____

7. What are the major sources of work that contribute to the household income? What percentage does each source of work you mentioned represent?

ITEM	Description	No. in household doing this activity	%
a. Crop Farming			
b. Livestock/Pastoral farming			
c. Hunting			
d. Fishing			
e. Tourism			
f. Vending			
g. Manufacturing/Industrial			
h. Construction/Labor			
i. Education/Research			
j. Healthcare			
k. Business			
l. Public Service			
m. Gifts/Inheritance			
n. Borrowing/Loans			
o. Government Assistance (Pension, Disability, Welfare)			
p. Community/Family Self Help Group (e.g. Sou sou)			
q. Remittances (Money sent from abroad, regionally, local urban areas, local rural areas)			
r. Other ___________________________			
TOTAL			

8. What are the major sources of food for the household? What percentage does each source of food you mentioned represent?

ITEM	% contribution
a. Household garden *i. Fruits ii. Roots iii. Vegetables*	
b. Household animals	
c. Hunting	
d. Fishing	
e. Plantation/Estate	
f. Local store	
g. Store outside of community	
h. Donations	
i. Exchange of goods	
j. Other (Please specify) ________________________________	

9a. Does your family have adequate food for the whole year? ☐ *Yes* ☐ *No*

9b. If no, how many months a year does your household have trouble getting enough food?

____

10. Where do you get your household drinking water? Please tick all that apply.

☐ Private Well ☐ Rural Intake ☐ Village pump/Well ☐ River/ Spring/ Lake
☐ Other ____

11. Please rate your household's access to:

	Poor	*Fair*	*Good*	*Very Good*	*Excellent*
Clean water (daily)	☐	☐	☐	☐	☐
Sewer/Sanitation services (daily)	☐	☐	☐	☐	☐

Regular electricity service (daily)	☐	☐	☐	☐	☐
Basic healthcare (as needed)	☐	☐	☐	☐	☐

12. Rank on a scale of 1-3 the level of difficulty / stress experienced each month of the year

(1 = easy month, 2 = normal month, 3 = difficult month)

Month	Rank
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

12b. Please explain why the months you chose are difficult

____

____

____

____

Knowledge/Awareness

1a. Do you think the weather is changing/ has changed? ☐ Yes ☐ No ☐ I don't know

1b. If yes, how?

____

____

____

____

2a. Do you think the weather changes are affecting/will affect your livelihood/ability to earn a living?

☐ Yes ☐ No ☐ I don't know

2b.If yes, how? If not, why not?

____

____

____

____

3a. Do you think weather changes are affecting/will affect your community? ☐ Yes ☐ No ☐ I don't know

3b. If yes, how? If not, why not?

____

____

____

____

4a. Do you think weather changes are affecting/will affect some community members more than others? ☐ Yes ☐ No ☐ I don't know

4b. If yes, in what way? If not, why not?

____

____

____

5. What changes in the environment have you noticed in the past 5-10 years? I will list a set of items. Let me know if you have seen any of these changes. Tick all that apply.

- ☐ Hotter
- ☐ More landslides
- ☐ More forest fires
- ☐ More coastal erosion
- ☐ Less/smaller crops
- ☐ No changes observed
- ☐ More flooding
- ☐ Heavier rainfall
- ☐ Drier watercourses/rivers
- ☐ Less fish
- ☐ Less plant life
- ☐ Other (Please specify) ________________________
- ☐ Stronger storm surges/bigger waves
- ☐ Longer dry periods/drought
- ☐ Higher sea levels
- ☐ Less turtle nesting
- ☐ More mosquitoes

6a. Do you think the changes observed in the environment over the past 5-10 years have been positive or negative?

☐ Positive ☐ Negative ☐ No changes observed

6b. If negative, are any of the following factors influencing changes over the past 5-10 years?

Tick all that apply.

- ☐ *Natural environmental/earth cycles*
- ☐ *Inadequate law enforcement*
- ☐ *Lack of public awareness/education*
- ☐ *Climate change*
- ☐ *Inadequate policies & legislation*
- ☐ *Other* ________________________

7a. Do you know of any local organizations/groups that deal with the environmental issues in your community? ☐ Yes ☐ No ☐ I don't know

7b. If yes, which ones?

____

____

____

____

8a. Do you know of any past or current projects that deal with environmental issues in your community? ☐ Yes ☐ No ☐ I don't know

8b. If yes, which ones?

____

____

____

____

Impacts

1. Please rank the environmental threats/stresses that are currently impacting the community? (Begin with the most significant threat/stress; you can use 0 if you do not think it is a threat to/impacting the community)

THREAT	RANK
Flooding	
Coastal Erosion	
Landslides	
Storms/Hurricanes	
Drought	
Sea Level Rise	
Other___________________________	

2. Please identify the type, date and duration of any weather related extreme events/disasters/periods of environmental stress that you remember or have experienced in the Matura to Matelot region?

EVENT DESCRIPTION	DATE	DURATION

3a. Were you or any of your family members ever negatively impacted by an extreme weather event/disaster/period of environmental stress? ☐ Yes ☐ No ☐ I don't know

3b. If yes, how?

- ☐ *Injured (Physical/Mental)/Lost family members*
- ☐ *Damaged/lost home*
- ☐ *Damaged /lost crops/animals*
- ☐ *Prolonged service interruption (e.g. no electricity/water for more than 24 hours)*
- ☐ *Physical/mental injury (Self)*
- ☐ *Damaged/lost property/machinery*
- ☐ *Blocked/loss of roads/access*
- ☐ *Loss of telecommunications (phone/internet)*
- ☐ *Other* ___________________________________

4. How much were you or any of your family members harmed by an extreme weather event/disaster/period of environmental stress?

☐ A great deal ☐ A moderate amount ☐ Only a little ☐ Not at all

5a. Has an extreme weather/disaster event/period of environmental stress affected your livelihood/ability to earn a living? ☐ Yes ☐ No ☐ I don't know

5b. If yes, how?

____

____

____

____

6a. Has an extreme weather/disaster event/period of environmental stress caused you to leave the region in order to earn a living? ☐ Yes ☐ No

6b. If yes, where did/do you go?

____

____

____

7. How likely do you think it is that an extreme weather event will cause a disaster/period of environmental stress in your community in the next 12 months:

☐ *Very likely* ☐ *Somewhat likely* ☐ *Somewhat unlikely* ☐ *Very unlikely*

Strategies: Preparedness

In the event of an extreme weather emergency / disaster:

1. How many days of water do you have stored to meet the needs of your household?

☐ *0 days* ☐ *1-2 days* ☐ *3-5 days* ☐ *6-7 days* ☐ *>7 days*

2. How many days of required medication/medical supplies (e.g. bandages, antiseptic, etc.) do you have stored to meet the needs of your household?

☐ *0 days* ☐ *1-2 days* ☐ *3-5 days* ☐ *6-7 days* ☐ *>7 days* ☐ *Not Applicable*

3a. Do you have an emergency kit in your home? ☐ Yes ☐ No ☐ I don't know

3b. If yes, what items are in the emergency kit? (Indicate Yes (√) or No (x) to each item).

☐ *Candles* ☐ *Matches* ☐ *Torchlight* ☐ *Battery operated radio* ☐ *Spare batteries*
☐ *Medicines/Medical supplies* ☐ *Other*____
_

4. Is anyone in the household trained in First Aid? ☐ Yes ☐ No ☐ I don't know

5a. Have you ever attended disaster preparedness training session? ☐ Yes ☐ No ☐ I don't know

5b. If yes, which one(s) and when?

____

____

____

6. Do you talk to your family about what to do in the event of an emergency? ☐ Yes ☐ No ☐ I don't know

7. Where do you get information about preparing for weather related events? (Mark (√) for those that are mentioned. Mark (X) for those that were prompted).

☐ *Television – Documentaries/ Government Information* ☐ *Television – News/Weather Reports* ☐ *Radio - Talk show/Special programs*
☐ *Family/Friends/Community members* ☐ *Commercials* ☐ *Internet*
☐ *School* ☐ *Work* ☐ *Church*
☐ *Community meetings* ☐ *I don't get any information*
Other ____

8. What are the major challenges your household faces in preparing for extreme weather events/periods of environmental stress? Please let me know if any of these apply.

- *Cannot move to a safer location*
- *Lack of savings*
- *Lack of employment alternatives*
- *Never experienced an event*
- *Other*_____________________________
- *Lack of money to build safer /protect housing*
- *Other issues are more important*
- *Don't know what to do*
- *Don't know when event will happen*

Strategies: Response

1. How long does it take you to get to the nearest health facility?

- *Less than 15 minutes*
- *15-30 minutes*
- *45 minutes*
- *1 hour*
- *More than 1 hour*
- *I don't know where is the nearest health facility*

2. Who do/would you call for assistance in the event of an emergency?

- *Fire, Ambulance*
- *Police*
- *Hospital*
- *Councilor/Government official*
- *Neighbors*
- *Religious leader*
- *Other family member/friend*
- *Disaster Management Unit*
- *Regional Corporation*
- *Office of Disaster Preparedness*
- *Other* ____

3. In the last extreme event/disaster, how did you respond during and/or immediately after the event?

- Used shelters provided by government agency
- Volunteered /worked at emergency facility
- Volunteered /worked on community disaster response team
- Moved family/friends/neighbors to different location
- Made contact with family/friends/neighbors
- Volunteered / worked on clean-up crew
- Nothing
- Other____

4. Did you receive a warning about the extreme weather event before it happened?	Yes	No	I don't remember

Strategies: Recovery

1a. In the first 1-3 months after the last extreme weather event/disaster, did you rely/lean on others for financial / food support?	Yes	No (Skip to Q.3)	Other

1b. If yes, which of the following types of support did you rely/lean on for money or food? Please tick all that apply.

- ☐ *Relatives in my village/community*
- ☐ *Relatives outside my village/community*
- ☐ *Non-relatives in my village/community*
- ☐ *Non-relatives outside my village/community*
- ☐ *Government assistance/program*
- ☐ *Church/Non-profit relief organization*
- ☐ *Private business/company*
- ☐ *Other*________________________________

1c. If yes, why do they allow you to rely/lean on them for money or food support?

- ☐ *It is their obligation*
- ☐ *They lean/rely on my household when they need support*
- ☐ *Other* ____

2a. After 12 months, did you rely/lean on others for financial / food support? ☐ Yes ☐ No ☐ I don't know

2b. If yes, which of the following types of support did you rely/lean on for money or food? Please tick all that apply.

- ☐ *Relatives in my village/community*
- ☐ *Relatives outside my village/community*
- ☐ *Non-relatives in my village/community*
- ☐ *Non-relatives outside my village/community*
- ☐ *Government assistance/program*
- ☐ *Church/Non-profit relief organization*
- ☐ *Private business/company*
- ☐ *Other*________________________________

2c. If yes, why do they allow you to rely/lean on them for money or food support?

- ☐ *It is their obligation*
- ☐ *They lean/rely on my household when they need support*
- ☐ *Other* ____

3. Which of the following statements best describes your household's ability to cope with the last weather extreme event/period of environmental stress?

- ☐ *Unable to cope*
- ☐ *Somewhat able to cope*
- ☐ *Able to cope without difficulty*

4. Which of the following statements best describes your household's ability to manage future weather extreme events/periods of environmental stress?

- ☐ *Unable to cope*
- ☐ *Able to cope with changes in income and food sources*
- ☐ *Able to cope without difficulty*

5. To cope with future weather extremes/disasters some people make changes. Do any of the following apply to you?

- ☐ *Rebuilding/Changed structures on existing house*
- ☐ *Moved to new house in safer location*
- ☐ *Increased household emergency supplies*
- ☐ *Changed income or food sources*

☐ *Increased savings or other financial assets (e.g. insurance)*
☐ *Added income or food sources*
☐ *Migration of one or more household members to another community in the region*
☐ *Migration of one or more household members outside of the region*
☐ *Other* ____

6a. In the last 12 months, has your household sold livestock, land or property to meet household needs due to extreme weather event/disasters/period of environmental stress? ☐ Yes ☐ No ☐ Not applicable

6b. If yes , which of the following statements best describes the extent to which your household has been able to recover/repurchase those assets?

☐ *Unable to recover/repurchase*
☐ *Able to recover/repurchase some of them*
☐ *Able to recover/repurchase all or more than what was sold*

7a. In the last 12 months, has your household sold small livestock, a phone, bicycle or other small items to meet household needs due to extreme weather event/disaster/environmental stress? ☐ Yes ☐ No ☐ Not applicable

7b. If yes, which of the following statements best describes the extent to which your household has been able to recover/repurchase those assets.

☐ *Unable to recover/replace*
☐ *Able to recover/replace some of them*
☐ *Able to recover/replace all or more than what was sold*

8. What are the main challenges your household faces/would face in recovering from the impacts of extreme weather events/disasters/periods of environmental stress?

☐ *Cannot work*
☐ *Ongoing physical/mental health impacts*
☐ *Costs of recovery (e.g. housing reconstruction, healthcare)*
☐ *Lack of insurance/savings*
☐ *Lack of financial /relief assistance*
☐ *Lack of emotional support/counseling*
☐ *Bureaucracy/Too much red tape*
☐ *Lack of employment alternatives*
☐ *Lack of Government support/ Politics*
☐ *Don't know what to do*
☐ *Other* ____

9. Rank using a scale of 1-5 the five most feasible strategies that can be implemented to increase the ability of communities in the Matura to Matelot region to cope with climate change and extreme weather events/ periods of environmental stress?

Type	*Strategy*	*Rank*
Physical /Technical	□ *Build more protective structures (e.g. seawalls)* □ *Improve the condition of critical infrastructure/amenities (e.g. roads, bridges, schools, electric, water)* □ *Introduce climate resilient technologies (e.g. drought resistant seeds)* □ *Community relocation/resettlement* □ *Other*___	
Environmental/Land Use	□ *Create more natural resource buffers (e.g. tree belts)* □ *Encourage better ecosystem management practices (e.g. Forest reserves, reforestation, mangrove rehabilitation, no slash & burn)* □ *Restrict land development* □ *Implement more community based environmental projects* □ *Other*___	
Capacity Building /Awareness	□ *Promote community education about climate risks (focus groups, consultations, cross-community meetings, school curriculum)* □ *Provide more information on available external relief/assistance programs* □ *Other*___	
Policy Enforcement	□ *Enforce better building codes and construction practices* □ *Fines for illegal/bad practices*	
Financial & Economic	□ *Enable easier access to disaster relief/assistance* □ *Promote sustainable economic development (e.g. Eco and cultural tourism industry)* □ *Other*___	
Maintain Status Quo	□ *Do nothing, accept the situation* □ *Do nothing, nothing will work* □ *Do nothing, these communities are already resilient* □ *Other*___	

<u>Personal Information</u>

1. What is your age?

□ *Under18* □ *18-29* □ *30-39* □ *40-49* □ *50-59* □ *60-69* □ *70-79* □ *80 and over*

2. What is your marital status? □ Single □ Married □ Common-Law □ Widower □ Divorced

3. How many years of formal school have you completed?

___

4. What is / are your occupation / occupations?

____

5. How long have you lived in the Matura to Matelot region?

☐ *<1 year* ☐ *1-5 years* ☐ *6-10 years* ☐ *11-15 years*

☐ *16-20 years* ☐ *>20 years*

6. How did you come to live in the Matura to Matelot region?

☐ *Born here* ☐ Moved for employment opportunities ☐ *Moved for marriage/ relationship*

☐ *Moved because of family* ☐ *Moved for change in surroundings / pace of life* ☐ *Moved for fishing/ agriculture opportunities*

☐ *Moved for business opportunities* ☐ *Other* ________________________

7. Do you own or rent your home? ☐ *Own* ☐ *Rent* ☐ *Other (Please specify)* ______________________________

8a. Do you own the land (have the deed) where your home is built? ☐ *Yes* ☐ *No* ☐ *Other (Please specify)* ______________________________

8b. If no, what arrangement (s) allow you to have access to the land?

☐ Formal land sharing agreement with state or private owner ☐ Informal agreement for use of State land

☐ Informal agreement for use of private land ☐ No formal/informal arrangements/agreements

9. Here is a card with several ranges of household income. Which letter best describes your household income?

☐ No income ☐ Less than $500 ☐ $500- $1000 ☐ $1100 - $2000 ☐ $2100 - $3000 ☐ $3100- $4000 ☐ $4100- $5000

☐ $5100- $6000 ☐ $6100- $7000 ☐ $7100- $8000 ☐ $8100- $9000 ☐ $9100- $10000 ☐ $10000 and over

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