Vulnerability to Climate Change in the Context of Multiple Stressors: the Case of Funafuti, Tuvalu

by

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ABSTRACT

VULNERABILITY TO CLIMATE CHANGE IN THE CONTEXT OF MULTIPLE STRESSORS: THE CASE OF FUNAFUTI, TUVALU

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University of Guelph, 2013

Advisor: Professor Barry Smit

It is widely accepted that the Pacific Islands are highly vulnerable to the impacts of climate change. Most research on climate change in this region focuses on scenarios of sea-level rise, with little attention given to how people in communities experience changing climatic conditions in the context of multiple stressors. This thesis employs a community-centred analysis that considers vulnerability to climate change in the context of biophysical, social, economic, and cultural stressors, in the case of Funafuti, Tuvalu. The methods purposefully avoid prompting respondents to discuss climate change. Findings indicate that vulnerability of the Funafuti community arises from the complex interaction of urbanization, overcrowding, changing livelihoods, cultural values, limited economic opportunities, and changing climatic conditions. This research suggests that community oriented empirical studies that incorporate local knowledge and examine climate change in the context of multiple stressors, can provide guidance for locally relevant adaptation initiatives.
ACKNOWLEDGEMENTS

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Fakafetai lasi to everyone who helped me set up my project in Tuvalu, and to all of the friends I made while living in Funafuti who made fieldwork one of the most rewarding and enjoyable experiences I have had. My fieldwork would not have been possible without the help of Alan Resture, and Merineta Kitara, my research assistant and saitaina. Thank you to the Funafuti community for welcoming me in the warm, friendly way of the South Pacific. Thank you to the most wonderful group of palagi whose friendship, generosity, and support I am so thankful for. This includes, Lucy, Kate, Dan, Rex, Maggy, Tony, Caitlyn, and Andy.

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# TABLE OF CONTENTS

## CHAPTER ONE: Introduction

1.1 Rationale .................................................................................................................. 1  
1.2 Research Aim and Objectives .................................................................................. 3  
1.3 Outline of Thesis ........................................................................................................ 5  

## CHAPTER TWO: Context for Research

2.1 Climate Change and the Pacific Islands ..................................................................... 7  
   2.1.1 Evolution of Research Approaches .................................................................. 7  
   2.1.2 Biophysical Impacts of Climate Change ......................................................... 11  
   2.1.3 Human Dimensions of Climate Change ......................................................... 14  
2.2 Vulnerability ............................................................................................................. 20  
2.3 Research Opportunities ............................................................................................ 22  

## CHAPTER THREE: Study Location

3.1 Pacific Islands ........................................................................................................... 24  
3.2 Funafuti, Tuvalu ....................................................................................................... 26  
   3.2.1 Physical Geography and Climate ..................................................................... 27  
   3.2.2 History ............................................................................................................ 30  
   3.2.3 Population Growth, Urbanization and Migration ........................................... 32  
   3.2.4 Present Community Context ......................................................................... 37  
   3.2.4.1 Villages, Amenities and Island Communities .............................................. 38  
   3.2.4.2 Land Tenure ............................................................................................... 40  
   3.2.4.3 Water Harvesting ....................................................................................... 41  
   3.2.4.4 Food ........................................................................................................... 43  
   3.2.4.5 Local economy and Livelihood Activities ............................................... 44  

## CHAPTER FOUR: Methodology

4.1 Research Approach ................................................................................................... 48  
4.2 Data Collection ......................................................................................................... 50  
   4.2.1 Development of the Case Study ...................................................................... 51  
   4.2.2 Local Research Assistant .............................................................................. 52  
   4.2.3 Interviews with Community Members ............................................................ 53  
   4.2.3.1 Sampling Strategy ....................................................................................... 53  
   4.2.3.2 Sample Size ............................................................................................... 55  
   4.2.3.3 Interview Structure ..................................................................................... 57  
   4.2.4 Key Informant Interviews ............................................................................... 60  
   4.2.5 Participant Observation ................................................................................... 60  
   4.2.6 Secondary Sources of Information ................................................................... 61  
4.3 Data Analysis ............................................................................................................ 62  

## CHAPTER FIVE: Current Vulnerability

5.1 Exposure-Sensitivities ............................................................................................... 64  
   5.1.1 Unprompted Responses .................................................................................... 65  
      5.1.1.1 Economy .................................................................................................. 66
5.1.1.2 Food
5.1.1.3 Water
5.1.1.4 Overcrowding
5.1.1.5 Culture
5.1.1.6 Extreme sea levels
5.1.1.7 Coastal erosion
5.1.1.8 Strong winds and cyclones
5.1.1.9 Temperature
5.1.1.10 Unpredictable weather
5.1.2 Prompted Responses
5.2 Adaptive Strategies and Capacity
5.2.1 Adaptive Strategies
5.2.1.1 Bear
5.2.1.2 Reactive, Short-term Behaviour Changes
5.2.1.3 Rely on the Market
5.2.1.4 Traditional Knowledge and Activities
5.2.1.5 Share
5.2.1.6 Aid and Government Intervention
5.2.1.7 Change of Location to Reduce Exposure
5.2.1.8 Modify Surroundings to Reduce Exposure
5.2.2 Opportunities and Barriers for Adaptation
5.2.2.1 Smallness and Isolation
5.2.2.2 High Cost of Living and Few Jobs, Low Wages
5.2.2.3 Overcrowding
5.2.2.4 Donor culture
5.2.2.5 Religious convictions
5.2.2.6 Radio communication
5.2.2.7 Social capital
5.2.2.8 Traditional knowledge and activities
5.3 Current Vulnerability to Climate Change
5.3.1 Water security
5.3.2 Loss of land and flooding
5.3.3 Local food security

CHAPTER SIX: Future Vulnerability .................................................................121

CHAPTER SEVEN: Conclusions ....................................................................127
7.1 Summary of Main Messages
7.2 Scholarly Contributions
7.3 Practical Contributions
7.4 Future Research Opportunities

REFERENCES CITED ..................................................................................135
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Description of Community Member Interview Sample by Village</td>
<td>56</td>
</tr>
<tr>
<td>4.2</td>
<td>Description of Community Member Interview Sample by Age and Sex</td>
<td>57</td>
</tr>
<tr>
<td>4.3</td>
<td>Interview Guide: Themes and Sample Questions</td>
<td>59</td>
</tr>
<tr>
<td>5.1</td>
<td>Conditions Affecting Lives and Livelihoods of People Living in Funafuti, Unprompted Responses</td>
<td>65</td>
</tr>
<tr>
<td>5.2</td>
<td>Adaptive Strategies Employed to Cope with Exposure-Sensitivities in Funafuti</td>
<td>88</td>
</tr>
<tr>
<td>5.3</td>
<td>Opportunities and Barriers for Adaptation in Funafuti</td>
<td>96</td>
</tr>
<tr>
<td>5.4</td>
<td>Components of Lives and Livelihoods in Funafuti Sensitive to Climatic Conditions</td>
<td>104</td>
</tr>
<tr>
<td>6.1</td>
<td>The implications of future climate change for community-identified climatic risks</td>
<td>122</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>The countries and subregions of the Pacific Islands region</td>
<td>25</td>
</tr>
<tr>
<td>3.2</td>
<td>Islands of Tuvalu</td>
<td>27</td>
</tr>
<tr>
<td>3.3</td>
<td>Population of Funafuti between 1866 and 2011 (compiled from Munro &amp; Hosking, 1992; Secretariat of the Pacific Community, 2005; Government of Tuvalu, 2011a)</td>
<td>34</td>
</tr>
<tr>
<td>3.4</td>
<td>Changes in land use and cover, as well as the distribution of houses and buildings in the central part of Fongafale Islet as it has developed over the period of 1896 to 2004 (from Yamano et al. 2007)</td>
<td>36</td>
</tr>
<tr>
<td>3.5</td>
<td>Map of the communities of Fongafale Islet of Funafuti Atoll</td>
<td>39</td>
</tr>
<tr>
<td>4.1</td>
<td>Analytical framework for vulnerability assessment (Ford &amp; Smit, 2004)</td>
<td>49</td>
</tr>
<tr>
<td>4.2</td>
<td>Coding scheme developed to analyze interview data</td>
<td>62</td>
</tr>
<tr>
<td>5.1</td>
<td>Nui maneapa surrounded by high water during a tide above 3m in October 2012</td>
<td>79</td>
</tr>
<tr>
<td>5.2</td>
<td>Above left: Squatter settlement surrounding burrow pit in Teone at normal tide. Above right: The same area during a tide above 3m in October 2012, showing flooding of the narrow footpath</td>
<td>80</td>
</tr>
<tr>
<td>5.3</td>
<td>Factors influencing the vulnerability of the Funafuti community to climate-related risks</td>
<td>105</td>
</tr>
<tr>
<td>5.4</td>
<td>Fualifeke (above, right), an islet in the northern part of Funafuti Atoll, showing erosion and accretion on different parts of the shoreline between 1984 and 2003. The same process described by a Funafuti elder (adapted from Webb &amp; Kench, 2010)</td>
<td>110</td>
</tr>
<tr>
<td>5.5</td>
<td>Mean sea level in Funafuti from 1977-2008 (adapted from Webb &amp; Kench, 2010)</td>
<td>112</td>
</tr>
<tr>
<td>5.6</td>
<td>Diagram illustrating the contributions to extreme sea levels. The combined factors of high tides and wind-generated waves are particular pertinent to the Funafuti community (adapted from Walsh et al., 2012)</td>
<td>113</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
<td>AusAID</td>
<td>Australian Aid</td>
<td></td>
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<tr>
<td>EKT</td>
<td>Ekalesia Keliano Tuvalu</td>
<td></td>
</tr>
<tr>
<td>ENGO</td>
<td>Environmental Non-Government Organization</td>
<td></td>
</tr>
<tr>
<td>ENSO</td>
<td>El Nino Southern Oscillation</td>
<td></td>
</tr>
<tr>
<td>GEF</td>
<td>Global Environment Facility</td>
<td></td>
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<tr>
<td>IPCC</td>
<td>International Panel on Climate Change</td>
<td></td>
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<tr>
<td>IWRM</td>
<td>Integrated Water Resource Management</td>
<td></td>
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<tr>
<td>MSL</td>
<td>Mean sea level</td>
<td></td>
</tr>
<tr>
<td>PACC</td>
<td>Pacific Adaptation to Climate Change</td>
<td></td>
</tr>
<tr>
<td>PWD</td>
<td>Public Works Department</td>
<td></td>
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<tr>
<td>SOI</td>
<td>Southern Oscillation Index</td>
<td></td>
</tr>
<tr>
<td>SOPAC</td>
<td>Secretariat of the Pacific Community Applied Geoscience and Technology Division</td>
<td></td>
</tr>
<tr>
<td>SPREP</td>
<td>South Pacific Regional Environment Programme</td>
<td></td>
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<tr>
<td>SST</td>
<td>Sea surface temperature</td>
<td></td>
</tr>
<tr>
<td>TANGO</td>
<td>Tuvalu Association of Non-Government Organizations</td>
<td></td>
</tr>
<tr>
<td>TMC</td>
<td>Tuvalu Media Corporation</td>
<td></td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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</tbody>
</table>
## TUVALUAN GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Translation/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>falevatie</td>
<td>compost toilet</td>
</tr>
<tr>
<td>fatele</td>
<td>local dance</td>
</tr>
<tr>
<td>fakalavelave</td>
<td>problem, difficulty, hindrance, interruption; anything that a person is required to</td>
</tr>
<tr>
<td></td>
<td>attend to, or involved in organizing</td>
</tr>
<tr>
<td>kaitasi</td>
<td>“eat from the same land”; native land; a piece of land belonging to a group of equal</td>
</tr>
<tr>
<td></td>
<td>landowners, members of a family</td>
</tr>
<tr>
<td>Kaupule</td>
<td>executive branch of the local government</td>
</tr>
<tr>
<td>maneapa</td>
<td>meeting hall</td>
</tr>
<tr>
<td>mulivaka</td>
<td>traditional knowledge of the sea, resources of the trees</td>
</tr>
<tr>
<td>pulaka</td>
<td>traditional Tuvaluan root crop</td>
</tr>
<tr>
<td>taisala</td>
<td>swampland</td>
</tr>
<tr>
<td>taula</td>
<td>dry spell</td>
</tr>
<tr>
<td>umu</td>
<td>local, open-air house; traditional house</td>
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</tbody>
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CHAPTER ONE: Introduction

1.1 Rationale

The Pacific Islands are widely considered to be among the most vulnerable places in the world to climate change (Barnett & Adger, 2003; Barnett & Campbell, 2010; Mimura et al., 2007; Nurse & Moore, 2005). Projections indicate that this region will likely be impacted by increases in air and sea-surface temperature (Ruosteenoja et al., 2003), changes in precipitation patterns (Lal et al., 2002), sea-level rise (Webb & Kench, 2010), changes in regional climate systems (Collins et al., 2010), and more intense tropical storms (Walsh et al., 2012). It is understood that these changes will have implications for Pacific Island communities; however, the ways in which these changes will affect communities, and the ability of communities to adapt to these risks is poorly understood (Barnett & Campbell, 2010; Kelman & West, 2009).

Traditionally, Pacific Islands have been sites of resilience in the face of extreme events and harsh environmental conditions (Campbell, 2009; Gaillard, 2007; Nunn, 2000). In order to survive, Pacific Islanders learned, and developed skills over many generations to maintain a balance between their livelihoods and their environment (Campbell, 2009, Macdonald, 1982; Resture, 2009). An analysis of traditional disaster risk reduction in the Pacific Islands indicates that traditional Pacific island communities coped with the impacts of natural disasters and extreme events without external intervention (Campbell, 2009; Veitayaki, 2009). The longevity of many Pacific Island societies has been facilitated by adaptations to changing conditions including food storage and preservation, settlement security, and community cooperation (Campbell, 2009; Resture, 2009; Veitayaki, 2009). However, Pacific Islands have been undergoing sweeping political, economic, social, and
cultural changes in recent decades, which have influenced the ability of communities to adapt to environmental stressors. These include rapid rural to urban migration, globalization, reduced social cohesion, rapid adoption of the cash economy, unemployment, breakdown of traditional lifestyles, dependence on aid, and increasing importance of formal education (Mimura et al., 2007; Veitayaki, 2009).

Given the limited progress of the international community on greenhouse gas emissions reduction, adaptation to climate change is widely recognized as an important response strategy in order for nations and communities to cope with current and future climate change (Adger et al., 2007; Burton et al., 2002). This involves understanding the ways in which societies will experience the impacts of climate change. However, to date, most of the research in the Pacific Islands has focused on the biophysical impacts of climate change, particularly sea-level rise, and has been obtained through scenario-based approaches that consider impacts on human societies on a large scale and on the basis of assumption (Barnett & Campbell, 2010; Kelman & West, 2009). These studies have provided valuable insights into the nature of future environmental change, but have proven to be of limited use for planning adaptation initiatives at the local level (Kelman & West, 2009). For the purposes of understanding adaptation, scenario-based approaches are limited in that they assume the characteristics of climate to which people are vulnerable, they analyze climate conditions in isolation from other conditions affecting lives and livelihoods, and they do not look at the processes through which climate stressors are experienced or the processes through which adaptation occurs (Burton et al., 2002; Fussel & Klein, 2006; Kelly and Adger, 2000; O’Brien et al., 2004). To facilitate adaptation, it is critical to understand, from the perspective of people, the ways in which communities will
experience and cope with climate stressors (Ford & Smit, 2004). Furthermore, adaptation interventions that address the outcomes of a single stressor in isolation, are unlikely to build adaptive capacity in the long term (O’Brien et al., 2009); thus, it is important to understand the complex ways in which climate stressors will interact with other political, economic, social, and cultural stressors at the local level to influence vulnerability.

It is evident that Pacific Islands face significant risks associated with climate change, yet research to date has provided insufficient insight to facilitate effective adaptation responses. This calls for a research approach that places communities at the centre of the analysis, seeks to understand how communities experience and manage climate conditions, and considers vulnerability to climate change in the context of biophysical, as well as social, political, economic, and cultural stressors. This thesis employs a conceptual model of vulnerability to characterize the ways in which people living in Funafuti, Tuvalu are vulnerable to climate change in the context of multiple stressors by focusing on the experiences of people.

1.2 Research Aim and Objectives

The aim of this research is to assess the vulnerability of people living in Funafuti, Tuvalu to risks associated with climate change in the context of multiple stressors. This aim is achieved through the following objectives:

1. Document the conditions that currently influence the lives and livelihoods of people living in Funafuti

In the context of this research, “conditions” refers to the circumstances or factors that affect the well-being of people. In particular, it refers to those that contribute to hardship, make life difficult, or stress livelihoods.
Conditions are identified through semi-structured interviews with people living in Funafuti. In the first part of the interview, respondents are asked, in an unprompted manner, to discuss the conditions affecting their lives and livelihoods. Second, respondents are prompted to discuss whether several predicted impacts of climate change are currently affecting their lives and livelihoods. The first part of the interview involves a deliberately unprompted line of questioning to gain insight into all conditions (both climate-related and other) affecting lives and livelihoods in Funafuti. This will allow for an analysis of vulnerability to climate change in the context of multiple stressors.

2. **Characterize the adaptive strategies employed to manage and cope with these conditions and the processes that have aided or constrained adaptations**

Several attributes for systematically characterizing adaptations have been proposed (e.g. Burton et al., 1993, p. 31; Lim et al., 2005; Smit et al., 1999; Wheaton and Maclver, 1999). In this research, adaptations are characterized according to commonalities in the processes through which they occur.

Aids and constraints to adaptations emerge from an analysis of the interview data. Understanding factors that influence or constrain a system's adaptive capacity are useful when considering the adaptive potential, or adaptive capacity, of a system.

3. **Assess community vulnerability in the future.**

Assessing community vulnerability in the future involves estimating future exposures-sensitivities based on likely changes in conditions, as well as estimating the capacity of Funafuti to adapt to future conditions based on current adaptive capacity, and future socio-economic and environmental projections.
1.3 Outline of Thesis

This thesis is divided into seven chapters. Chapter 2, Context for Research, positions the thesis amid two relevant themes in the literature. The first section outlines the approaches that have been taken for gaining insight into the implications of climate change in the Pacific Islands. It also summarizes what is known about the biophysical and societal implications of climate change in this region. The second section reviews the concept of vulnerability, and the various approaches that have been used in vulnerability assessments. This section follows the evolution of vulnerability assessments from impact assessment through first and second generation assessments which progressively begin to include non-climatic determinants of exposure-sensitivities and adaptive capacity. It also outlines the theoretical framework employed in this research. The chapter ends by highlighting the research opportunities that this thesis addresses.

Chapter 3, Study Location, provides the regional and local context for the community case study including a description of local characteristics that influence how the community experiences and manages changing conditions. This is followed, in Chapter 4, Methodology, by a detailed outline of the empirical framework and methods employed, including the development of the case study, sampling strategies, interview design and structure, the role of secondary sources, participant observation, and data analysis.

Results for the first two research objectives are presented in Chapter 5, Current Vulnerability. In the first section of this chapter, Exposure-Sensitivities, the conditions that affect lives and livelihoods in Funafuti are identified and discussed. The second section, Adaptive Strategies, provides a discussion of the types of adaptive strategies that are employed in Funafuti to cope with stresses to lives and livelihoods, as well as the barriers
and opportunities for adaptive action. This chapter concludes with a section that characterizes the nature of vulnerability to risks specifically related to climate change. It does this by, first, teasing out the exposure-sensitivities and adaptive strategies that are related to climate change, from those that are less so, and second, discussing interconnections between factors that influence exposure-sensitivities. While this analysis focuses on climate-related vulnerabilities, the discussion incorporates climatic and non-climatic drivers of exposure-sensitivity and adaptive capacity to ensure the integration of multiple stressors.

Chapter 6, Future Vulnerability, presents the results for the third research objective. Current exposures are examined in light of future climate change projections to provide insights into the nature of future climate-related exposure-sensitivities. Similarly, adaptive capacity is examined relative to anticipated changes in social and economic conditions, which are expected to influence the nature of future adaptations. Finally, the thesis concludes with Chapter 7, Conclusions, which summarizes key research findings, identifies their scholarly and practical contributions, and discusses possibilities for future research to be conducted in the Pacific Islands.
CHAPTER TWO: Context for Research

This chapter reviews two themes of literature pertinent to the research presented in this thesis. The first section documents what is known about the implications of climate change in Pacific Islands, and outlines the approaches that have been taken to gain these insights. The second section examines the concept of vulnerability and the various approaches used in vulnerability assessments. It also describes the theoretical background for the research approach employed. Finally, gaps in the literature are identified and discussed.

2.1 Climate Change and the Pacific Islands

It is widely accepted that small island states, including those in the Pacific, are highly vulnerable to the impacts of climate change (Barnett & Adger, 2003; Ebi et al., 2006; Kelman & West, 2009; Mimura et al., 2007; Nurse & Moore, 2005). This oft-cited assertion is based on the high degree of exposure of small islands to sea-level rise, as well as assumptions about their susceptibility to harm from changing environmental conditions, and limited adaptive capacity (Barnett & Campbell, 2010, p. 11; Mimura et al., 2007). Approaches to conducting research on climate change in the Pacific Islands have evolved over the last several years, and research has produced some insights into the nature of climate change impacts and adaptation in the region.

2.1.1 Evolution of research approaches

The evolution of approaches to studying climate change in the Pacific Islands region parallels the development of approaches in the broad field of climate change impact assessment. The first stage of research focuses on impact assessments based on climate change scenarios. This approach, often called the scenario-based approach or top-down
approach, begins with predicted changes in human population, economies, and technological growth, and combines them with projections of future greenhouse gas emissions trends to project various scenarios of future climate (mainly norms in temperature, precipitation, etc.), which are then used to assess the biophysical impacts of climate change. Some research has taken this process one step further by modeling impacts of future changes in climate norms on socioeconomic systems, and some go further to identify hypothetical adaptive options and estimate residual impacts on systems at the end of the assessment (Carter et al., 1994; Parry & Carter, 1998; Smit & Pilifosova, 2001).

Notwithstanding the valuable insights of scenario-based approaches, for the purpose of understanding adaptation these approaches are limited in a number of ways. First, this approach requires the researcher to make assumptions about the climate conditions that must be adapted to and about the adoption of possible adaptive measures (Burton et al., 2002). Second, because the scenario-based approach was developed to assess the biophysical impacts of climate change it pays little attention to the processes through which adaptation occurs (Burton et al., 2002; O’Brien et al., 2004; Kelly and Adger, 2000). Third, scenario-based approaches tend to address the impacts of climate change in isolation from other stressors (Fussel & Klein, 2006).

To facilitate adaptation, alternative approaches have emerged in the climate science community. These approaches focus on vulnerability assessment for the purpose of informing adaptation initiatives, and are often called community-based approaches or bottom-up approaches. Their contribution is less to assess impacts of climate change and more to understand how societies are susceptible to climate change in order to guide adaptation initiatives. Vulnerability assessments place communities at the centre of
analyses in order to identify (rather than assume *a priori*) the attributes of a changing environment (including climate) that are important for lives and livelihoods in a community, as well as the various other stresses and conditions that shape exposures, sensitivities and adaptive capacities (Ford & Smit, 2004; Fussel & Klein, 2006). These approaches identify and document the processes that occur on a local level, by employing participatory, bottom-up methods that engage community members and local decision makers. Among the insights from this work on vulnerability in communities are susceptible to multiple stressors, and climatic stimuli are experienced as a part of a dynamic environment.

That the way in which people experience and cope with conditions that affect their lives and livelihoods occurs in the context of social, cultural, economic and political conditions and processes, is not a novel concept (see O’Keefe et al., 1976; Sen 1981), but it has emerged relatively recently in the field of climate change vulnerability. Increasingly, vulnerability assessments are employing approaches that examine multiple stressors (O’Brien et al., 2009; Turner et al., 2003; Wisner et al., 2004). For example, O’Brien et al. (2004) use the term “double-exposure” to examine the combined effects of climate change and economic globalization on India’s agriculture sector, while Belliveau et al. (2006) have investigated the role of “multiple exposures” in the grape industry in a Canadian region.

In the Pacific Islands region, as in the broad field of climate change, there has been a shift toward community-based approaches that provide insight into the impacts of climate change and adaptive capacity in the region (e.g. Bridges & McClatchey, 2009; Kuruppu & Liverman, 2011; Rasmussen, et al., 2009; Sutherland et al., 2005). These approaches promote collaboration and effective communication between researchers and
communities, participatory methods, and the inclusion of local voices (Daly et al., 2010; Dumaru, 2010; Fazey et al., 2010; Kelman 2010; Rudiak-Gould, 2012). However, understanding of how Pacific Islanders experience and respond to changing conditions is still at an early stage of development (Barnett & Campbell, 2010, p. 80; Mimura et al., 2007).

Additionally, much of the work on climate change in the Pacific Islands region focuses on climate in isolation from other stressors. Pacific Island societies have changed dramatically in recent decades. They have been stressed by external pressures such as globalization and have experienced changing internal conditions such as rapid population growth, rising incidence of poverty, political instability, unemployment, reduced social cohesion and rising inequality (ADB (Asian Development Bank), 2004; Veitayaki et al., 2007). These changes affect the ways in which Pacific Islanders experience and manage climatic conditions (Cocklin, 1999; Mimura et al., 2007); yet only recently have studies that consider the impacts of climate change in the context of multiple stressors begun to emerge in the Pacific Islands region (e.g. Nagashima, 2010; Schwarz et al., 2011; Reenberg et al., 2008).

Locally oriented empirical studies of vulnerability and adaptation that incorporate community perspectives on climate change, and consider multiple stressors, would greatly improve knowledge of the human dimension of climate change in the Pacific Islands region (Barnett & Campbell, 2010, p. 80; O’Brien et al., 2009).
2.1.2 Biophysical Impacts of Climate Change

Research in the Pacific Islands region has recorded observed trends in changing biophysical conditions, and produced insights into the nature of biophysical impacts that will likely affect the Pacific Islands region in the future as a result of climate change.

The average air temperature in the Pacific Islands region has shown consistent warming trends throughout the 20th century (Trenberth et al., 2007). By the end of this century, air temperature is projected to increase by up to 3.1°C relative to 1961-1990 average temperatures (Ruosteenoja et al., 2003). This projection may be conservative, given that there have been decadal increases in air temperature of between 0.3°C and 0.5°C since the 1970s (Salinger, 2001).

Analyses of observed trends in extreme daily rainfall across the Pacific Islands region show patterns that are not regionally uniform (Griffiths et al., 2003). Future projections indicate that it is unclear whether there will be an increase or decrease in mean annual rainfall (Lal et al., 2002; Ruosteenoja et al., 2003); however, there is evidence to suggest that rainfall events will become less frequent and more intense in the future (Dore, 2005; Griffiths et al., 2003; Jones et al. 1999; Lal et al., 2002; Mimura et al., 2007).

The El Nino Southern Oscillation (ENSO) phenomenon is a key factor in interannual climate variation in the Pacific Islands region. ENSO, or more commonly, El Nino describes a state of anomalous oceanic and atmospheric conditions in the Pacific Ocean. Under normal conditions, trade winds blow westward across the equatorial Pacific Ocean forcing warm surface water toward Papua New Guinea. The westward flow allows colder waters to upwell along the west coast of South America and reduces rainfall in that area. An El Nino event is characterized by a reversing of the trade winds, and high surface
temperatures in the eastern equatorial Pacific bringing drought to most of the Pacific Islands and Australia. A La Nina event is the opposite of an El Nino event during which eastern Pacific waters are cool and the southern United States experiences drought, as do some Pacific Islands. In the last 50 years or so there has been a clear trend to more negative values of the Southern Oscillation Index (SOI), meaning more frequent and severe El Nino events (Walsh et al., 2012). Yet, there is uncertainty about the effect of climate change on ENSO, therefore, there is little confidence in whether the amplitude or frequency of ENSO is likely to change in the future (Collins et al., 2010; Walsh et al., 2012).

Climate change is predicted to impact the marine environments of Pacific Islands due to the combined influence of sea-surface warming and ocean acidification. Tropical sea-surface temperatures have been rising for the past 50 years (Reaser et al., 2000), and are projected to continue rising (Mimura et al., 2007). In addition, the rising concentration of carbon dioxide in the atmosphere leads to ocean acidification by increasing the concentration of carbon dioxide in the ocean (Feely et al., 2009; Hoegh-Guldberg et al., 2007). The impacts of sea-surface warming and acidification include decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease (Hoegh-Guldberg & Bruno, 2010).

Tropical storm frequency, intensity, and location may also be altered as a result of climate change. The frequency of tropical cyclones in the future is likely to either decrease or stay the same (Henderson-Sellers et al., 1998; Meehl et al., 2007; Salvat & Wilkinson, 2011; Walsh et al. 2012); a prediction in accordance with the observation that the number of cyclones in the southwest Pacific Ocean basin has decreased between the mid-1990s and
mid-2000s (Webster et al., 2005). Some predictions suggest that the peak wind speed and precipitation intensities of cyclones, as well as the number of intense cyclones will increase in the future (Meehl et al., 2007; Salvat & Wilkinson, 2012; Walsh, 2004), which is also consistent with the observed trend that the number of category 4 and 5 storms in the South-West Pacific more than doubled from the period 1975-1989 to the period 1990-2004 (Webster et al., 2005). Whether a decrease in cyclone frequency will lead to an overall decrease in the total number of intense cyclones remains uncertain (Walsh et al., 2012). Also, there is an expectation that tropical cyclone genesis locations and tracks may change in response to climate change, no consensus has emerged (Walsh et al., 2012). The genesis and tracks of cyclones are strongly influenced by the ENSO and other phenomena that are not yet predictable (Henderson-Sellers et al., 1998; Mimura et al., 2007). Some models predict no change in cyclone formation regions, other predict cyclones forming further north and others further south (Walsh et al., 2012).

Finally, sea-level rise is the most commonly cited impact of climate change in the Pacific Islands. Sea level in the Pacific Islands region has been rising on the order of 2.0mm/year for the past 20 to 30 years (Webb & Kench, 2010). Projections of sea-level rise by the end of the 21st century range from 0.19 to 0.58 m (Meehl et al., 2007). Sea-level rise of this magnitude poses many problems for Pacific Islands including: inundation and flooding, coastal erosion and saltwater intrusion (Mimura, 1999). It is a possibility that several Pacific Islands will lose significant proportions of their land, and that coastal regions, if not entire islands, will become uninhabitable (Barnett & Adger, 2003; Kelman & West, 2009; Mimura, 1999).
2.1.3 Human Dimensions of Climate Change

Knowledge on the human dimensions of climate change in the Pacific Islands is still at an early stage of development (Mimura et al., 2007). While there has been a recent shift toward community-based approaches that examine the ways in which communities experience and respond to changing conditions, to date, there are still few empirical studies of vulnerability in the region. Most of what is known about the implications of climate change in Pacific Island communities is inferred based on scenario-based approaches that predict changes in the biophysical environment and consider impacts on human societies on the basis of assumption (Barnett & Campbell, 2010, p. 69; Kelman & West, 2009). Perhaps the most widely cited implication of climate change in the Pacific Islands is that of displacement as a result of rising sea levels. The Pacific Islands are frequently portrayed as drowning islands, and Pacific Islanders represented as soon-to-be climate refugees by popular media, the scientific community, environmental non-government organizations (ENGOs), and the leaders of Pacific Island states. Despite these dominant representations, there is considerable uncertainty in the details of the ways in which Pacific Island societies will be impacted by climate change. Research has provided enough insight to broadly determine that climate change will affect water resources, human health, food security, human settlement, and island economies, yet research regarding sensitivity to stressors and the adaptive capacity of Pacific Island communities has only begun to emerge in the last several years. This section aims to review what is known about the human dimensions of climate change in the Pacific Islands.

The most recent International Panel on Climate Change (IPCC) report suggests (with very high confidence) that water resources in small islands are likely ‘to be seriously
compromised’ by climate change (Mimura et al., 2007). This assertion is inferred based on evidence related to the way in which climate change will alter the supply side of water resources. For example, it is noted that less frequent rainfall events may lead to more intense droughts which will be problematic in terms of water availability for human consumption, and for food production (Barnett & Adger, 2003; Hay et al., 2003; Mimura et al., 2007). Also, coastal erosion and decreased rainfall correspond to reductions in the sizes of freshwater lenses in small islands that are a critical source of freshwater in some places (Barnett & Adger, 2003; Mimura et al., 2007; White et al., 2007). Finally, saltwater intrusion into freshwater resources may result from sea-level rise and storm surges (Barnett & Adger, 2003; Mimura et al., 2007; White et al., 2007). While these insights are relevant, there are limited in that they do not attend to the sensitivity of Pacific Island societies to these aspects of water resource availability, and they do not provide insight into the capacity of Pacific Islanders to manage water resources under stress.

The health of Pacific Islanders may also be adversely affected in a variety of ways including morbidity and mortality from extreme weather events, vector-borne diseases, and food- and water-borne diseases (Ebi et al., 2006). The potential future health impacts of climate change in small island states that are of greatest concern include malaria, dengue fever, diarrheal diseases, heat stress, skin diseases, acute respiratory infections, and asthma (Ebi et al., 2006, Singh et al., 2001). Specifically in the Pacific Islands, there is concern that warmer sea surface temperatures will lead to higher incidences of ciguatera seafood poisoning, which is a type of fish poisoning that occurs after consuming ciguatoxin-contaminated fish and causes a range of acute neurologic, gastrointestinal, and cardiac
symptoms, with some experiencing chronic neurologic symptoms lasting weeks to months (Hales et al., 1999; Skinner et al., 2008).

Food security in Pacific Islands is also likely to be affected by climate change that may cause stress to agriculture and fisheries. Agricultural production is likely to be compromised by the effects of erosion, contamination of freshwater by saltwater intrusion, cyclones and storm surges, heat stress, and drought (Barnett, 2011; Mimura et al., 2007). Fisheries may be adversely impacted by increasing temporal and spatial variability in fish abundance caused by the degradation of reefs and mangroves, increased sea-surface temperature and changes in ENSO (Barnett, 2011; Mimura et al., 2007). Climate change may also impact fisheries production through storm damage to boats and fishing facilities (Barnett, 2011). Bell et al. (2009) demonstrate that fish still provide a majority of animal protein in Pacific Island communities, and posit that this dependence leaves them vulnerable to food insecurity in the future, in part because of climate change. While this literature points to the exposure and sensitivity of Pacific Island communities to food security risks associated with climate change, less work has been done on how communities deal with changing conditions that affect their food supply.

Perhaps the most widely cited potential impact of climate change for Pacific Islanders is that of the displacement of human settlements. Several authors have argued that human settlements in Pacific Islands are at risk of inundation from sea level rise due to their high degree of exposure in low-lying, coastal areas (Barnett & Adger, 2003; Edwards, 1999; Gravelle & Mimura, 2008; Mimura & Nunn, 1998). The concept of climate refugees has become the subject of a great deal of discussion, not only in academic literature, but in popular media, and international negotiations on climate change. While climate change
poses serious risks to the sustainability of Pacific Island communities, especially in atolls (Barnett & Adger, 2003), it is important to note that the assumption that sea level rise will force the migration of Pacific Islanders from their homes may be premature (Mortreux & Barnett, 2009). Most of the research that has supported these claims has focused on the exposure of biophysical systems, with much less research into the capacity of these systems to adapt. Recent work on this topic has indicated that concerns about the impacts of climate change are not currently a significant driver of migration in the region, and that there are a suite of factors influencing population dynamics and migration in Pacific Islands (e.g. rural to urban migration, economic opportunity), only one of which is climate change (Mortreux & Barnett, 2009; Locke, 2009).

Finally, the economies of the Pacific Islands are likely to be stressed by climate change. Fisheries and tourism are among the main sources of income in the Pacific Islands region and both are likely to be adversely affected by changing climatic conditions (Becken, 2005; Becken & Hay, 2007; Mimura et al., 2007; Nurse & Moore, 2005). Although there is considerable uncertainty regarding the spatial and temporal details, tourism is vulnerable to the impacts of coral bleaching, storm damage, sea level rise, freshwater availability, as well as transportation and communication interruption (Becken, 2005; Becken & Hay, 2007; Hoegh-Guldberg et al., 2007; Nurse & Moore, 2005).

In recent years, research on adaptation processes in Pacific Island societies has started to emerge. This work has examined traditional knowledge to gain insight into past and present coping strategies, the barriers and aids to adaptation in Pacific Island communities, and the adaptation process in the context of contemporary cultural change, and multiple stressors.
Work focusing on the examination of traditional knowledge includes Bridges and McClatchey (2009), who conducted an ethnoecological study at Rongelap atoll in the Marshall Islands and found that these Pacific Islanders actively manage the water, land, and food resources that are most likely to be affected by climate change. Resture (2009) conducted a similar analysis on the ways in which Tuvaluans cope with risks associated with tropical cyclones. Others have argued that indigenous knowledge for disaster risk management and reduction exists throughout the Pacific Islands, and that the key elements of adaptive management were built around food security, settlement security, and community co-operation (Campbell, 2009; Veitayaki, 2009). It has been argued that this knowledge should be applied in the development of disaster management initiatives if such initiatives are to be adopted and effective (Lefale, 2010; Veitayaki, 2009).

Work on the barriers and aids to adaptation in Pacific Island communities has also provided insights into the adaptation process. Barnett (2008) found that aid can have both positive and negative effects on adaptive capacity, and posits that it must be delivered with care and purpose if the adaptation it is intended to facilitate is to be effective, and not increase vulnerability to climate change. Veitayaki (2009) made similar observations with regard to the negative effect that aid can have on the self-efficacy of Pacific Island communities. This is an important insight given that self-efficacy is known to play a key role in adaptation initiative and increased resilience in small island states in the Pacific and elsewhere (Kuruppu & Liverman, 2011; Tompkins, 2005).

Other studies have found religion, perceptions, awareness, short-term planning perspectives, traditional governance structures, community cohesion, good leadership, and collective action also play roles in adaptation in Pacific Island communities (Kuruppu,
2009; Lata & Nunn, 2012). For example, Kuruppu (2009) demonstrates that religion is a significant factor in the adaptation process in the water sector in Kiribati, because power structures in the church preclude benefits to the individual, so that people are hindered from pursuing individual adaptation strategies.

Some recent work has also aimed to understand societal responses to change in the context of multiple stressors. Fazey et al. (2011) illustrate that key drivers of population growth and a strong desire for monetary prosperity act in concert to generate stress in communities, and that people tend to respond by focusing on income generation, which is reinforcing stress in communities. Schwarz et al. (2011) conducted an analysis of vulnerability and resilience in three remote communities in the Solomon Islands and found that a combination of internal conditions such as the erosion of social values, and external forces such as climate change were of concern to the communities.

Literature on the human dimensions of climate change in the Pacific Islands has identified some sectors and broad components of livelihoods likely to be affected by climate change. Most of these insights are based on scenario-based approaches, and are therefore limited in their ability to account for the ways in which communities experience and cope with changing conditions. Several authors have called for more empirical research into the ways in which communities are sensitive to stressors associated with climate change, and how they cope with changing conditions (Barnett & Campbell, 2010, p. 80; Schwarz et al., 2011). Other authors have highlighted the need to understand the multidimensional nature of drivers of change and societal responses (Reenberg et al., 2008).
2.2 Vulnerability

Vulnerability has a variety of definitions in different research disciplines, but there is broad agreement that it refers to the susceptibility of a system (e.g. community) to harm relative to a stimulus or stimuli (Smit & Wandel, 2006). The concept has evolved in a variety of research fields, including natural hazards (Burton et al., 1993; Cutter et al., 2003; Hewitt, 1983), food security (Dilley & Boudreau, 2001; Sen, 1981; Watts & Bohle, 1993), political ecology (Blaikie et al., 1994; Wisner et al., 2004), national security (Homer-Dixon & Blitt, 1998), environmental change (Kasperson et al., 1995; Liverman, 1990), and sustainable livelihoods (Chamber & Conway, 1992; Turner et al., 2003). In the climate change field, vulnerability is a key concept relating to adaptation in both the scholarly and policy debates. It is explicitly referred to in the United Nations Framework Convention on Climate Change (UNFCCC, 1992), where countries commit to promote adaptation to address vulnerable regions and peoples. The concept of vulnerability is now widely used to understand the implications of climate change in communities (Adger, 2006; Ford & Smit, 2004; Fussel and Klein, 2006).

Interpretations of the concept of vulnerability vary. In many climate change impact studies, vulnerability refers to the residual effects of modeled climate change impacts minus hypothetical adaptation (O'Brien et al., 2004). This conceptualization is sometimes referred to as end-point vulnerability (O'Brien et al., 2004).

Another interpretation of vulnerability focuses on the state of a community or system that makes it susceptible to harm. This conceptualization is sometimes referred to as starting-point vulnerability (O'Brien et al., 2004). In this conceptualization, the vulnerability of a system to climate change is considered a function of a system's exposure
and sensitivity to changing conditions and the system's adaptive capacity to deal with those conditions (Adger, 2006; Adger & Kelly, 1999; Burton et al., 2002; Ford & Smit, 2004; Kasperek & Kasperek, 2001; Smit & Pilifosova, 2001; Turner et al., 2003; Yohe & Tol, 2002). Rather than residual impacts, this conceptualization of vulnerability refers to “the degree to which a system to susceptible to, or unable to cope with, adverse effects of climate change, including climate variability or extremes” (Smit et al., 2000).

Exposure refers to the characteristics of physical stimuli (e.g. magnitude, frequency, duration, etc. of hurricanes, droughts, etc.), while sensitivity describes the nature of the system (e.g. location of community, livelihoods, economy, infrastructure, etc.) (Burton et al., 2002; Kelly & Adger, 2000; O'Brien et al., 2004; Smit & Wandel, 2006). Exposure and sensitivity are considered here as a single property of a system to reflect the fact that physical stimuli are not necessarily considered exposures unless the system is in some way susceptible to changes in that condition. For example, a condition (sometimes referred to as a risk or stressor) such as drought would be considered an exposure in a community, only if that community is susceptible to harm by way of water shortage.

Adaptive capacity refers to a system's potential ability to adapt or adjust to exposure-sensitivities, to moderate damages, to take advantage of opportunities or to cope with consequences of climate change (IPCC, 2007). Adaptive capacity is context-specific and varies by location, across scales, and over time (Smit & Wandel, 2006). At the community level, adaptive capacity is influenced by factors such as access to financial, technological and information resources, the institutional environment, political influence, social capital, etc. (Adger, 2003; Adger & Kelly, 1999; Smit & Pilifosova, 2001).
2.3 Research Opportunities

“Despite longstanding recognition that the Pacific Islands are very vulnerable to climate change, there have been few locally oriented empirical studies of vulnerability in the region.”

(Barnett & Campbell, 2010, p. 80)

The bulk of what we know about climate change in the Pacific Islands region is focused on the biophysical environment and has been obtained through scenario-based approaches that consider impacts on human societies on the basis of assumptions about relevant stimuli, sensitivities, and adaptive strategies (Barnett & Campbell, 2010, p. 69; Kelman & West, 2009). Scholarship on vulnerability in a variety of fields has come to recognize that vulnerability of a system is a function of not only biophysical stressors, but also of the social context in which those stresses are experienced and managed (Cutter, 1993; Smit & Pilifosova, 2003). It is clear that understanding of the human dimensions of climate change in the Pacific Islands is limited by the conceptualizations of vulnerability and the approaches to studying vulnerability that have been employed in the region to date. There is an opportunity to gain further insight into the nature of vulnerability in the region by employing an approach that documents (rather than assumes) the nature of exposure-sensitivities, and analyzes the ways in which people respond to conditions that affect their lives and livelihoods. In order to do this it is necessary to gather insights from the experiences of people in communities, which involves placing communities of the centre of analyses and incorporating local voices. It is also necessary to document the multidimensional nature of stresses in communities in order to accurately characterize the way in which people experience and respond to changing conditions. This thesis responds to this research opportunity by employing a conceptual model of vulnerability to
characterize the ways in which people living in Funafuti, Tuvalu are vulnerable to climate change in the context of multiple stressors.
CHAPTER THREE: Study Location

This chapter provides the regional and local context for this research by presenting information on the Pacific Islands region and a description of Funafuti, Tuvalu. This includes Funafuti’s physical geography and climate, history, population and present community context. This research assesses vulnerability to climate change at the community scale; therefore, an understanding of local conditions that influence how the community experiences climate change is central to this research.

3.1 Pacific Islands

The Pacific Islands region encompasses 22 countries and territories in the Pacific Ocean (Figure 3.1). The region comprises great cultural, geographic, and development diversity within small parcels of land scattered across a hug swathe of the Pacific Ocean.

The region is often divided into three subregions: Melanesia, Polynesia, and Micronesia. This division is based on 19th century perceptions of racial and cultural groupings that is not entirely accurate but remains a standard frame of reference. Melanesia includes the relatively large, culturally and linguistically diverse island states in the South-West Pacific Ocean. The Polynesian countries are relatively culturally similar despite that they are located great distances apart. Micronesia is composed of the large number of small island states near the equator.

The Pacific Islands are geographically diverse in terms of land area, elevation, and island type. Island types in the Pacific region include plate-boundary islands, volcanic islands, atolls, and raised limestone islands. Countries like Guam, Nauru, and Niue consist of a single, small island, while others like Solomon Islands, Tonga, Cook Islands, and French Polynesia comprise numerous islands of various sizes that are widely dispersed. The total
land areas range from 12km² for groups of low-lying coral atoll islands like Tokelau, to approximately 460 000km² for plate-boundary islands like Papua New Guinea.

Furthermore, the Pacific Islands are politically and developmentally diverse. Many of the Pacific Island countries are fully independent (e.g. Fiji, Kiribati, and Samoa), some are dependent territories (either of France, the United States, or New Zealand), and others are self-governing and constitutionally independent but maintain an association with either the United States or New Zealand (e.g. Marshall Islands with the United States, and Cook Islands with New Zealand). Economic development also varies greatly from one Pacific Island country to another. Gross National Income per capita ranges from US$ 1 110 in Solomon Islands to US$ 6 510 in Palau (ADB, 2013). Kiribati, Samoa, Solomon Islands, Tuvalu, and Vanuatu are classified by the United Nations as Least Developed Countries.

![Map of the Pacific Islands](image)

**Figure 3.1:** The countries and subregions of the Pacific Islands region
3.2 Funafuti, Tuvalu

Tuvalu is a Polynesian country composed of nine coral atolls, located between longitude 5° and 11° south and latitude 176° and 180° east in the Pacific Ocean (see Figure 3.2). Atolls are rings of coral reefs that enclose a lagoon. Tuvalu is one of only 5 countries worldwide that is composed entirely of atoll islands. Tuvalu is the fourth smallest nation in the world with a total land area of 26km², and the maximum elevation is 5m above sea level. Tuvalu's population of approximately 10 000 is unevenly distributed among the 9 islands. Funafuti, the capital island, is an urban centre relative to the rural outer islands and hosts approximately 5 000 people. Tuvalu is also considered a Least Developed Country by the United Nations. Recently, Tuvalu has received much attention in the media and at international climate change negotiations because it is considered one of the most vulnerable nations in the world to climate change.

Field work for this research took place in Funafuti, Tuvalu. This section describes Funafuti’s physical geography and climate, history, and population and present community context to situate the ways in which climate change is experienced by the local people.
Figure 3.2: Islands of Tuvalu

3.2.1 Physical Geography and Climate

As shown in Figure 3.2, Funafuti is among the central group of Tuvalu’s 9 low-lying coral atoll islands. Funafuti is a typical atoll with a lagoon of approximately 18km in diameter at its widest and a discontinuous string of islets along its edges. With the exception of a handful of families living on Funafala Islet, Funafuti’s population is concentrated on the largest islet, Fongafale, which is about 12km long on the east side of the lagoon, and is approximately 142 hectares in size.

Fongafale Islet is characterized by a wide central area (approximately 570m across) narrowing into two thin strips of land to the north and southwest. A topographic profile of the central area reveals an oceanward storm ridge, a central depression, and a lagoonward beach ridge (Yamano et al., 2007). The highest elevation on Fongafale Islet is
approximately 5m above mean sea level (MSL) on the oceanward storm ridge, while the lagoonward beach ridge is about 2.5m above MSL, and the central depression is only approximately 1m above MSL (Yamano et al., 2007).

Atoll soils are primarily made up of carbonate reef-borne material minimal, and are not very fertile. Coconut palms thrive, and pandanus trees are common in Funafuti, but the vegetation is not very diverse. The central depression of Fongafale Islet was originally dominated by taisala (swampland) containing mangroves, small trees and bushes, although much of the taisala was reclaimed during the construction of the airfield there in 1942 (Yamano et al., 2007).

Tuvalu has two seasons, a wet (“bad weather,” according to the locals) season from November to March and a dry (“good weather”) season from April to October. Tuvalu lies within the trade wind zone; the easterly trade winds blow most of the time in Funafuti except during the wet season when the westerly winds take their place (Koch, 1961; McLean & Hosking, 1992). The temperature year-round is relatively constant averaging 28° Celsius (Australian Bureau of Meteorology and CSIRO, 2011). Funafuti has the highest annual rainfall of all 9 islands at approximately 3500mm annually (McLean & Hosking, 1992). Annual rainfall varies considerably from one year to another with a max of 5140.7mm recorded in 1997 and a minimum of 2054.9mm recorded in 2011 (Tuvalu MET Service, 2012).

In Funafuti, rain falls frequently in brief, heavy showers. A few consecutive days without rain is uncommon; however, historical monthly average rainfall data shows that long periods with very little rainfall occur and these are sufficient to cause severe domestic water shortages and drought conditions (McLean & Hosking, 1992). Funafuti’s local
climate conditions are part of a broader regional picture dictated by the El Nino Southern
Oscillation (ENSO) phenomenon (McLean & Hosking, 1992). In years of very strong La
Nina events (characterized by strong trade winds, and a positive SOI), Funafuti is subject to
very dry conditions called, taula, in Tuvaluan (T. Katea, personal communication,
September 26, 2012). Conversely, in years of very strong El Nino events (characterized by
weak trade winds, and a negative SOI), Funafuti receives very wet weather (T. Katea,
personal communication, September 26, 2012).

Strong westerly winds occur at intervals during the wet, bad weather period from
November until March. Tropical cyclones occasionally begin to develop close to Tuvalu, but
it is rare for Tuvalu to suffer a direct hit from a hurricane. Most often, if a tropical cyclone
develops close to Tuvalu, a strong wind warning will be issued, but Tuvalu will be impacted
by the windflow toward that system rather than the system itself (T. Katea, personal
communication, September 26, 2012). Funafuti has been affected by major tropical
cyclones in the past that have caused serious damage. Particularly notable was the
December 1883 hurricane (McLean & Hosking, 1992), and more recently Hurricane Bebe in
October 1972 that resulted in 6 deaths, left 800 people homeless, and the overnight
formation of a massive rubble rampart along the eastern coastline of Funafuti (Maragos et
al., 1973).

Daily, variation in sea level in Funafuti is driven predominantly by tides. Tuvalu
experiences semidiurnal-dominant tides (i.e. two approximately equal high tides and low
tides each day). Extreme sea levels in Tuvalu are the result of several coinciding processes
including astronomical tides, the seasonal sea level cycle, the ENSO, and severe weather
events such as tropical cyclone. In Funafuti, sea level extremes tend to occur in February or
March as a result of peaks in the spring tide, and because of the seasonal sea level cycle, which is a maximum at that time (Australian Bureau of Meteorology, 2010; Merrifeld et al., 2007). La Nina events are associated with high regional sea levels and, therefore, tend to also coincide with extreme sea levels in Funafuti (Merrifeld et al., 2007). Tuvalu rarely experiences direct exposure to tropical cyclones; however, their impacts occasionally reach Funafuti and contribute to extreme tides as well (Australian Bureau of Meteorology, 2010; Walsh et al., 2012).

3.2.2 History

“Of necessity, a delicate balance between man and nature was retained.”

(Macdonald, 1982, p. 5)

Tuvalu was among the last of the Polynesian islands to be occupied by people. Evidence indicates that the islands of Tuvalu (with the exception of Niulakita) were originally occupied between the early 14th century and the mid-17th century as part of a westward movement of established Polynesian communities (Macdonald, 1982, p. 3). Legends and language indicate that the original Tuvaluans were likely of Samoan origin; however, there is also significant Tongan influence in the northern islands, and significant Kiribati influence in Nui.

From whatever origin, the life of the original islanders was very difficult. Living on small pieces of land just a few metres above sea-level, upon infertile soils in the remote Pacific Ocean made survival extremely challenging (Macdonald, 1982, p. 3). In order to survive, Tuvaluans “learned to live within the limits imposed by their environment” (Macdonald, 1982, p. 13), and became “complete masters of their environment” (Koch, 1961, p. 12).
It was not until the 1820s that all the islands of Tuvalu had been sighted by Europeans. The earliest known sighting of Funafuti was in 1819 by the British vessel “Rebecca,” captained by Arent Schuylet de Peyster (Koch, 1961, p. 12; Macdonald, 1982, p. 16). It was Peyster who gave the Tuvaluan islands their original name, the Ellice Islands, when he called Funafuti Atoll “Ellice’s group” after his patron Edward Ellice.

In the 1860s, Peruvian labour recruiters known as “blackbirders,” raided the easily accessible atolls of the Ellice Islands and captured dozens of Ellice Islanders (Bedford et al., 1980; Macdonald, 1982, p. 54). Also, in the 1860s Samoan missionaries began the systematic Christianisation of the islands (Macdonald, 1982, p. 40). Samoan missionaries spread the Christian faith, introduced their language, and modified the traditional way of life with a new social order and cultural change (Macdonald, 1982, p. 73). In 1892, Tuvalu was united with Kiribati (formerly the Gilbert Islands) as a British Protectorate known as the Gilbert and Ellice Islands Protectorate (Macdonald, 1982, p. 70). Britain later annexed the islands and they became a Colony in 1916 (Macdonald, 1982, p. 114).

World War II marked another important time in the history of Funafuti. The attack on Pearl Harbour on December 7, 1941 sparked the beginning of the war in the Pacific. In October 1942, the American military established a presence in Funafuti (and later Nukufetau and Nanumea) to serve as a base for American attacks on the Japanese positions in the Gilberts (Macdonald, 1982, p. 143; McQuarrie, 2008). During the period of American occupation, the military dominated the Funafuti people and their environment (Macdonald, 1982, p. 143). To construct an airfield in the widest section of Fongafale Islet, the Americans executed an extensive reclamation of taisala by excavating large amounts of fill material from the northern and southern ends of the islet, as well as southern parts of the
storm ridge (McQuarrie, 2008; Yamano et al., 2007). The excavated pits in the southern and northern parts of the island remain today and are referred to as “burrow pits.” Since WWII there have been no further major alterations in the landform of Fongafale islet with the exception of the accretion of the storm ridge that occurred in 1972, when Hurricane Bebe resulted in the overnight formation of a massive rubble rampart along the eastern coastline of Funafuti (Maragos et al., 1973).

The colonial boundary drawn around the Gilbert and Ellice Islands began to crumble when Ellice Islanders’ demanded separation from the Gilberts in the mid-1960s (Macdonald, 1982, p. 243). Formal, administrative separation of the Ellice from the Gilbert Islands occurred on January 1, 1976. Funafuti became the new administrative centre of the Ellice Islands, which were henceforth known as Tuvalu, meaning “cluster of eight,” a traditional name for the island group excluding Niulakita which was uninhabited at the time (Macdonald, 1982, p. 257). Less than three years later on October 1, 1978 Tuvalu became an independent nation within the Commonwealth, and Funafuti became the capital of an independent nation.

3.2.3 Population Growth, Urbanization and Migration

“No country in the Pacific region has experienced more recent or more rapid internal migration and urbanization than Tuvalu.”

(Connell, 1999)

Data on the population of Tuvalu prior to 1965 are unreliable, though it is clear that prior to colonial intervention there were extensive controls on population. As food scarcity resulting from drought was common, control measures that included abortion and infanticide were practiced in order to maintain balance between population and resources (Bedford et al., 1980; Connell, 1999; David, 1913). These traditional forms of population
control were abolished by missionaries, contributing to the rapid growth in population in
the later half of the 19th century (Connell, 1999; David, 1913).

Historically, Funafuti has been one of the least populated islands in Tuvalu. In the
mid-19th century, the population of Funafuti was approximately 300 (Bedford et al., 1980;
Macdonald, 1982, p. 54). In the 1860s, raids by blackbirders dramatically reduced Islander
populations in both Nukulaelae and Funafuti by 80 percent and 60 percent, respectively
(Bedford et al., 1980). In the later half of the 19th century and the first half of the 20th
century, the population of Tuvalu grew steadily largely in response to the abolition of
traditional population control measures (Connell, 1999). Growth became more rapid after
WWII, largely due to the extension of modern medical services to the remote British
colony, but increased markedly in the 1970s (Connell, 1999). Between 1973 and 1979, the
population of Funafuti grew from 871 to 2120 as a result of the closure of the phosphate
mines on Banaba Island (formerly Ocean Island) and Nauru, where many Tuvaluans were
laborers, return migration from Kiribati from which Tuvalu had separated, and migration
from outer islands (Connell, 1999) (see Figure 3.3). In 1973, Funafuti’s population was less
than that of Nanumea, Vaitupu and Niutao, but by 1979 it was unchallenged as the most
populated important island in the new nation (Munro & Hosking, 1992). During the 1980s,
Funafuti’s prominence continued to develop as it was the new national capital, and its
population grew to 3839 in 1991 (Connell, 1999). Today, the population is more than 5000
(Government of Tuvalu, 2011a).
**Figure 3.3:** Population of Funafuti between 1866 and 2011 (compiled from Munro & Hosking, 1992; Secretariat of the Pacific Community, 2005; Government of Tuvalu, 2011a)

Funafuti’s proportion of the national population increased from 15% in 1973 to nearly half the national total by the mid-1990s (Connell, 1999; Munro & Hosking, 1992). Extensive rural to urban migration continues from the outer islands to Funafuti today. The rapid in-migration of Tuvaluans from outer islands to the capital is driven by a variety of factors including employment opportunities, medical care, education, leisure, and curiosity about the modern lifestyle.

The population of Funafuti has increasingly become concentrated on just one islet, Fongafale. Before 1972, there were about 100 people living on Funafala, an islet in the
southern part of the Funafuti Atoll. In response to Hurricane Bebe in 1972, most families moved to Fongafale (Connell, 1999). With the exception of a handful of families that have subsequently returned to Funafala, the entire population of Funafuti resides on the single islet of Fongafale.

Long before Funafuti was the capital island of Tuvalu, the small population of indigenous Funafuti Islanders living on Fongafale Islet (recorded at only 100 inhabitants in 1866 after the Peruvian raids) lived in two villages called Senala and Alapi, located on the lagoonward beach ridge. By the 1970s, the population had expanded to the point where the beach ridge was fully developed with houses and other buildings. Since then the population has expanded into the low-lying areas in the central depression of Fongafale Islet and to the thin strips of land to the north and southwest. The low-lying areas in the central depression of Fongafale correspond to the original taisala that was reclaimed during the construction of the airfield in 1942. These low-lying areas are below the high water level and are prone to flooding during exceptionally high tides, especially those in the spring (T. Katea, personal communication, September 26, 2012; Yamano et al., 2007). Figure 3.4 shows the changes in land use and cover, as well as the distribution of houses and buildings in the central part of Fongafale Islet as it has developed over the period of 1896 to 2004. The thin strips of land to the north and south were formally bush lands where the locals maintained gardens, kept animals and harvested local foods from trees.
Figure 3.4 Changes in land use and cover, as well as the distribution of houses and buildings in the central part of Fongafale Islet as it has developed over the period of 1896 to 2004 (from Yamano et al. 2007)
The rapid urbanization of Funafuti has caused many difficulties. In-migration of outer islanders to the capital has long caused tension between the indigenous Funafutians and the migrants from outer islands. As early as the mid-1970s, “[d]emands for restriction of entry to the capital were being expressed by women’s committees and island councils in Tuvalu: the outer islands seeking to retain active young people; Funafuti seeking to retain its separate identity” (as cited in Connell, 1999, p. 13). Since then these issues and resentments have persisted but have not amounted to policy formation (Anonymous, personal communication, October 8, 2012). Many of the issues that result from urbanization in Funafuti are not different from those experienced in urban centers in other developing countries: overcrowding in households, difficulties in achieving adequate service provision, unemployment, squatter settlements, poor nutrition and crime (Connell, 1999). The urbanization of Funafuti is one of the defining characteristics of the present community.

3.2.4 Present Community Context

The present community of Funafuti is a bustling urban centre relative to the peaceful calm of the rural outer islands. In recent decades, Funafuti has experienced sweeping social, cultural, economic and environmental changes. These have included: a decline in the participation of subsistence activities such as harvesting of pulaka, fishing and gathering of local foods, a diminished taste for locally harvested foods, and a preference for store bought, processed foods, transition to a cash economy, rapid urbanization and population growth, changes in land tenure, increasing importance of formal education, and declining social cohesion. This section describes the current local
setting including a description of communities, land tenure, water and food procurement, local economy and livelihood activities.

3.2.3.1 Villages, Amenities, and Island Communities

The main islet of Fongafale hosts 7 villages, shown in Figure 3.5. Senala and Alapi are located on the lagoonward beach ridge and are the original villages of Funafuti where most of the indigenous Funafuti Islanders reside. Southwest of Alapi is Vaiaku, the administrative centre and host to the Government Building, as well as a small residential area. East and northeast of Senala is Fakaifou, which means new town in Tuvaluan. Fakaifou was established during the 1970s and 1980s to accommodate the rapidly growing population. Teone is a small village northwest of Fakaifou that includes the Funafuti wharf and one of Funafuti’s most obvious squatter settlements on the oceanward side surrounding a burrow-pit. Lofeagai and Tekavatoetoe are the villages in the extreme north and south ends of the islet. These are the most recently settled areas of Fongafale. Formerly bush areas, they are largely settled by outer island families that have moved to Funafuti in search of work.
**Figure 3.5**: Map of the communities of Fongafale Islet of Funafuti Atoll

In addition to the government headquarters, Funafuti hosts the national hospital, Telecom communications company, the Red Cross, a satellite campus of the University of the South Pacific, a hotel and guesthouses, restaurants, and numerous small shops. The international airport and a deep-sea wharf in Funafuti provide the only link between Tuvalu and Fiji. Cargo ships arrive every few weeks with bulk goods and two planes per
week provide vital links for medical supplies and services, mail, imported foods, and passengers.

Since roughly three quarters of people living in Funafuti are native to outer islands, the capital also hosts a unique blend of outer island communities. Tuvaluans living in Funafuti remain very loyal to their home island, and each outer island community has a meeting hall called a maneapa in which community gatherings, feasts, and celebrations take place.

3.2.3.2 Land Tenure

The national motto of Tuvalu is “Tuvalu mo te Atua” meaning “Tuvalu for God.” One Tuvaluan describes his view of land ownership by saying, “[a]ll of this [land], this belongs to God, we are just here to occupy [it].” Traditionally, Tuvaluans have valued their land above all other possessions (Faaniu et al., 1983).

In Tuvalu, land tenure is governed by kaitasi. Literally translated into English, kaitasi means “eat from the same land.” Kaitasi refers to those people who are living on, or eating from a piece of land as equal landowners (Tuvalu Lands Code, 2008). Kaitasi property is listed under the name of the head of a family group and includes a list of family members who are equal owners. Rules surrounding kaitasi vary slightly among islands in Tuvalu. In Funafuti, all members in the kaitasi group must agree upon any decisions affecting kaitasi land, and lands cannot be sold, although they can be exchanged or leased (Tuvalu Lands Code, 2008).

In order to accommodate the development of Funafuti and the large population of outer Islanders, a large proportion of land on Fongafale Islet has been leased to the government, businesses and individuals by Funafuti landowners. This land is referred to as
leased land, and tenants are entitled to use a piece of land belonging to a Funafuti landowner for a set period of time in exchange for payment.

3.2.3.3 Water Harvesting

In Funafuti, the only source of freshwater is rainfall. Fongafale Islet, unlike many other atoll islands, has no thick freshwater lens (Bailey et al., 2009). Prior to the construction of the airfield in 1942, Fongafale Islet was only 250-300m wide, which was insufficient for formation of a thick freshwater lens. Even though the Islet is now 700m wide due to the reclamation of the *taisala* for the airstrip, the porous material used for the reclamation has prevented the artificial formation of a freshwater lens (Nakada et al., 2012). Thus, rainwater catchment systems are a part of nearly every house and building. Rainwater is collected from roofs via gutters that drain into large tanks beside houses and buildings. There are also two large cisterns on the island (one under the Government Building, and one beside the Funafuti *maneapa*), and a third is under construction. The cistern under the Government Building is used for the sale and distribution of freshwater among households in need. The cistern beside the Funafuti *maneapa* is used by the Funafuti island community for distribution among community members in need, and for storage in case of water shortage.

Since Funafuti usually receives about 3500mm of rain per year, this system of water harvesting has usually been adequate for the community’s needs. During the rainy months from November to March there is more than enough water to supply the population of Funafuti. During the dry season from April to October there are occasional dry spells during which times water supplies can run low in some households. During these periods,
people in Funafuti respond by budgeting their water, buying water from the government or asking their communities if they can take some water from the tank at their *maneapa*.

In 2011, Tuvalu experienced an extreme dry spell brought on by a very strong La Nina event. After several months of less than average rainfall, stores of freshwater were depleted to such a low level that the Government of Tuvalu declared a state of emergency on September 28, 2011.

Since the water harvesting system is vulnerable to periods of dry weather, Tuvalu has received a great deal of international aid to strengthen the resilience of their water harvesting systems. Between 2007 and 2012, a total of 2292 water tanks have been donated for distribution to households in Tuvalu. This total represents the combined efforts of various projects and agencies including the Secretariat of the Pacific Community Applied Geoscience and Technology Division (SOPAC), Australian Aid (AusAID), the European Union, and the United States Agency for International Development (USAID). Occasionally, these programs have included water catchment systems (e.g. gutters) and system maintenance in their programs, but not always.

In addition to donations of tanks for individual households, there are two ongoing capacity-building projects related to the water sector in Tuvalu. One is the Pacific Adaptation to Climate Change (PACC) project, executed by the South Pacific Regional Environment Programme (SPREP), implemented by the Public Works Department (PWD), and funded by the Global Environment Facility (GEF). The PACC project was guided by an approach similar to the vulnerability approach employed in this research. After consulting with the Funafuti community members living in Lofeagai, the focus of the project has been the construction of a community water cistern beside the new Ekalesia Kelisiano Tuvalu
(EKT) Chapel. As of October 2012, the cistern was still under construction. It is hoped that the cistern will supplement the water tanks of individual households and provide additional storage to enhance the resilience of the community in the event of future water shortages.

The other ongoing project is the Integrated Water Resource Management (IWRM) project, executed by SOPAC, implemented by the PWD, and funded by GEF. The focus of the IWRM project in Tuvalu has been the promotion of the composting toilet (falevatie). This initiative aims to promote water conservation by replacing flush toilets with composting toilets that do not require water, and improve wastewater management by diverting waste from the poorly constructed and maintained septic systems in Funafuti. As both projects are ongoing, their effectiveness has yet to be evaluated.

A major issue with household water harvesting systems in Tuvalu is that they are often not properly installed and they tend to be not well maintained. Many tanks in Funafuti sit beside houses but are not connected to gutters. Some tanks sit beside a house connected to a gutter from one side of a house, but the other side of the roof does not have a gutter and that water goes to waste. Many gutters and tanks leak. Because so many homes in Funafuti are leased and because so much of the water harvesting system has been donated by foreign aid, there is an apparent disparity in the understanding of where responsibility lies in the maintenance of Tuvalu’s water harvesting system.

3.2.3.4 Food

The food system in Funafuti has been altered dramatically by the modernization of the island as Tuvalu’s capital. The original, pre-colonial, food system in Tuvalu was based primarily on fisheries and coconut, and was supplemented by the cultivation of the local
root crops *pulaka* and taro (David, 1913; Koch, 1961). Europeans and missionaries later encouraged the cultivation of bananas and breadfruit, which are also now considered local foods in the traditional diet.

Today, rice is the staple food in the diet of Tuvaluans living in Funafuti. It is said that the rice was introduced to the Tuvaluan diet when labourers from Ocean Island and Nauru, who were fed rice while working for the British Phosphate Commission, returned to Tuvalu (I. Lausaveve, personal communication, October 17, 2012).

Traditionally, all food consumed in Tuvalu was harvested from the land and the sea. In modern Funafuti, most of the food consumed is bought from a store or sent from families living in the outer islands. Most families maintain a few pigs kept in pens on the periphery of residential areas to be consumed on special occasions. Some families have taken to raising chickens, and maintaining small gardens outside their homes growing bananas, pawpaw, cucumber and pumpkin.

Only indigenous Funafuti Islanders own land on which they can maintain a *pulaka* pit. However, it has been estimated that approximately 80% of the *pulaka* pits on Funafuti have been abandoned. Reasons for such a high degree of abandonment likely include: young people are not taking an interest in learning the practice of cultivation; migration of indigenous Funafuti Islanders away from Funafuti; salt water intrusion of pits during high tides; drought; and changing food preferences in favour rice instead of local foods like *pulaka* (I. Lausaveve, personal communication, October 17, 2012).

3.2.3.5 Local Economy and Livelihood Activities

The local economy and livelihood activities in Funafuti are very different from those in the outer islands of Tuvalu. In comparison to the rural, subsistence livelihoods of
Tuvalu’s outer islands, the local economy in Tuvalu is driven by wage labour, primarily in the public sector. However, economic activity in Funafuti is not particularly diverse because Tuvalu has struggled to develop economically.

Tuvalu is recognized by the United Nations as a Least Developed Country. Tuvalu’s economic development is constrained by a variety of factors including its limited resource base and distance from major markets (Government of Tuvalu, 2011b). Its small and open economy is vulnerable to external influences including fluctuating aid flows and commodity prices (Connell, 2003). Tuvalu is heavily dependant on aid and overseas remittances, which account at least one-third of GDP and 20 percent of national income, respectively (Barnett & Campbell, 2010, p. 7; Connell, 2003). Remittances in Tuvalu are mainly from seafarers working on foreign fishing vessels as well as family members working in New Zealand or Australia. Another important source of income for Tuvalu is fishing license fees. License fees paid by foreign-operated fishing boats to fish within the territorial waters of Tuvalu amount to over 40 percent of GDP (ADB, 2002, p. 51).

Difficulties in achieving economic development have resulted in Tuvalu pursuing some unusual development strategies at times. The sale of postage stamps has long been an important domestic industry (Connell, 2003). Renting the Tuvaluan telephone country code (688) earned approximately $3 million AUD per year until it was ended on moral grounds as it turned out that sex companies were the major renters (Connell, 2003). Very profitable has been the leasing of the international Internet domain name (.tv) (Bennetts & Wheeler, 2001). Recently, Tuvalu has fallen under international scrutiny for becoming a “flag of convenience” state, whereby Tuvalu has allow foreign shipping companies to flag
their vessels with Tuvaluan flags to avoid international sanctions (Bradsher, 2006; Paivar, 2012).

As a result of limited opportunities for economic development, economic activity is overwhelmingly dominated by the public sector (Connell, 2003; Government of Tuvalu, 2011b). Approximately two-thirds of all employment in Tuvalu is in the public sector (Connell, 2003). Since about 85% of public sector jobs are located in Funafuti (Government of Tuvalu, 2011b), opportunity for employment is one of the main pull factors for migration from the outer islands to the capital.

Household income in Funafuti is derived from employment in the public sector and in projects financed by aid, as well as private sector activities such as small businesses. Other important sources of household income include the selling of handicrafts and goods from subsistence activities like fishing, as well as property income and remittances (Barnett & Campbell, 2010, p. 8; Government of Tuvalu, 2010).

The employment rate in Funafuti in 2004 was 50% of the population for individuals aged 15 years and older (Government of Tuvalu, 2011b). The unemployment rate among youth aged 15-24 in Funafuti is approximately 56%, although the statistics are outdated (Government of Tuvalu, 2011b). The high youth unemployment rate reflects the oft-cited issue that school-leavers and Amatuku Maritime Training Institute graduates are unable to find jobs in Funafuti.

The communal nature of Tuvaluan culture has prevented the poor economic development of Tuvalu from causing people to live in poverty as defined by starvation and homelessness (Government of Tuvalu, 2011b). Rather, hardship in Tuvalu is linked to ‘poverty of opportunity,’ meaning that while almost all Tuvaluans have access to adequate
shelter and food through their social networks, they lack access to employment, land, and basic services (ADB, 2003; K. Saloa, personal communication, September 27, 2012). Many people do not have sufficient financial resources to cover basic needs, expenses, and need to make trade-offs among expenditure priorities. For example, many families need to decide between the purchase of food items, or school fees and contributions to the church, or utility bills (ADB, 2003).
CHAPTER FOUR: Methodology

The research presented in this thesis was carried out in several phases. Theoretical and context study for this research took place between September 2011 and April 2012. Research planning and design occurred in May and June of 2012, and fieldwork was carried out between July and October 2012. Data analysis and writing of the research findings occurred between November 2012 and June 2013.

The purpose of this chapter is to explain the research approach, provide a detailed outline of the empirical methods employed and describe the process of data analysis involved in fulfilling the objectives of the work. As outlined in Chapter 1, the objectives are as follows:

1. Document the conditions that currently influence the lives and livelihoods of people living in Funafuti

2. Characterize the adaptive strategies employed to manage and cope with these conditions and the processes that have aided or constrained adaptations

3. Assess community vulnerability in the future.

4.1 Research Approach

This research employs a conceptual model of vulnerability described in Chapter 2, Section 2.2. In this model, vulnerability to climate change is a function of exposure of the community to climate change-impacts and its adaptive capacity to cope with that exposure. This particular model was developed in the climate change field, and is known as the ‘vulnerability approach.’ The research framework for empirically applying this conceptualization of vulnerability has two stages and is described in detail in Ford and Smit (2004) (Figure 4.1).
Figure 4.1: Analytical framework for vulnerability assessment (Ford & Smit, 2004)

The first stage of this research framework is to assess ‘currently vulnerability.’ This involves the identification of conditions, risks, or stressors (climate related and other) that are relevant to the people in the community (referred to as exposure-sensitivities), and the documentation of strategies employed in the community to cope with and adapt to exposure-sensitivities. It also involves the identification of processes and conditions that have aided or constrained adaptations as an insight into adaptive capacity. An important element of the vulnerability approach is that the researcher does not presume to know the
exposures and sensitivities that are pertinent to the community, nor does the research establish, in advance, the determinants of adaptive capacity (Smit and Wandel, 2006). Rather, these are identified from the community itself via research methods that engage community members, stakeholders and decision makers as well as the integration of information from other sources. The stage is consistent with objectives 1 and 2 of the research presented in this thesis.

The second stage is to assess ‘future vulnerability’. This involves estimating future risks or exposure-sensitivities based on likely changes in conditions that have been identified as important to community livelihoods and assessing the capacity of the community to adapt to future conditions based on current adaptive capacity, and future socio-economic and environmental projections. This stage is consistent with objective 3 of the research presented in this thesis.

Information in the two stages of the vulnerability approach was obtained primarily from data collected through semi-structured interviews with community members and key informants. Secondary sources of information and participant observation were complimentary sources of data.

4.2 Data Collection

Data collection took place in Funafuti for 3 months between July and October 2012. Local collaborators were essential to the process of selecting a case study location and carrying out the fieldwork portion of this research. Methods used to gather information included interviews with community members, key informant interviews, participant observation, and analysis of secondary sources of information. This section covers the
development of the case study, the local research assistant, and the 4 methods used to gather data.

4.2.1 Development of the Case Study

A variety of people from several Pacific Island countries were contacted in order to find a study location where the type of research would be well received by a local community, and would either complement an ongoing research project or be useful for community development. Contact was made with Alan Resture, a Tuvaluan PhD Candidate at the University of Auckland in New Zealand, agreed to support a project of this nature, through providing contacts and an orientation to Tuvaluan customs, including protocols for carrying out research.

Sandra McCubbin and Alan Resture arrived in Funafuti on July 24, 2012 and spent 10 days meeting community representatives and local authorities to discuss the research, become familiar with the community, and determine the focus of, and best site for, the research. Formal and informal meetings between the researcher and local people in Funafuti were made. Several hours each day were spent walking and biking around the community visiting the Government Building, Kaupule Town Council, Tuvalu Campus of the University of the South Pacific, Princess Margaret Hospital, Tuvalu MET Services, Public Works Department, Integrated Water Resource Management programme office, Tuvalu Association of Non-Government Organizations (TANGO), Red Cross, meeting community members, attending church services and attending community celebrations such as a fatele. This familiarization with Funafuti was extremely helpful in gaining an appreciation of local customs, protocols, and developing rapport among community leaders.
The information gathered during the first ten days indicated that a vulnerability assessment employing the ‘vulnerability approach’ that was broad in scope would be feasible and a useful research project. Funafuti was chosen as the study site due to concerns about the logistics of outer island transportation and accommodation. The researcher prepared a draft interview guide, which was translated into Tuvaluan by Alan Resture. Prior to Alan Resture’s departure, he and Sandra McCubbin carried out one interview with an elder of the Funafuti community to ensure that the interview guide was appropriate.

4.2.2 Local Research Assistant

During the first 10 days of the research period in Funafuti, the researcher and Alan approached the teachers of the Form 7 (senior secondary) school to ask if they could suggest a current or former student, fluent in both Tuvaluan and English, who might be interested in assisting with the research project. The teachers suggested a young woman named Merineta Kitara.

The researcher and Merineta met to discuss the focus of the research, commitment required by a research assistant, as well as compensation. The arrangement was agreeable to both Merineta and the researcher, and Merineta was hired. Her responsibilities included facilitating interviews with community members, attending interviews, translating between Tuvaluan and English during and after interviews, and advising on proper etiquette during interviews. She was compensated with a wage that was consistent with youth employment wages in the community.
4.2.3 Interviews with Community Members

Since the aim of this research is to document the vulnerability to risks associated with climate change from the perspective of local people, interviews with community members represented the key source of information. Over a period of three months, 40 semi-structured interviews were conducted with a cross section of community members to identify the conditions that have affected, and are currently affecting the lives and livelihoods of people living in Funafuti; to understand the strategies employed to cope with and adapt to these conditions; and, to document factors that influence adaptive capacity to risks.

4.2.3.1 Sampling Strategy

The main aim of the sampling strategy was to obtain a cross-section of adults (eighteen years or older) in Funafuti. In this research, it was considered important to obtain a sample that was broadly representative of the Funafuti population, but not necessary to obtain a sample that was statistically generalizable. To ensure the sample was broadly representative of the diverse perspectives of people living in Funafuti, the sample was stratified by age and sex. Also, people living in different areas of Fongafale Islet experience differential exposure to various risks; therefore, the cross-section of adults was also stratified by village. Research that is field oriented in nature and not concerned with statistical generalizability often uses nonprobabilistic samples (Guest et al., 2006). Three types of nonprobabilistic sampling were used to obtain interviews with community members; purposive sampling, quota sampling, and snowball sampling.

The first sampling strategy applied in this research to was purposive sampling. In purposive sampling, the researcher decides the purpose they want respondents to serve,
and they find participants to serve that purpose (Bernard, 2000; p. 176). This research required respondents who were living in, rather than just visiting, Funafuti.

Second, a quota sampling strategy was applied. In quota sampling, the researcher decides the subpopulations of interest, and the proportions of those in the final sample (Bernard, 2000; p. 175). In this research, after consultation with members of the Red Cross and TANGO organizations, the researcher decided that the experiences and perspectives of adults living in Funafuti might vary depending on sex, age, and village of residence. Therefore, it was determined that the final sample should contain about half males and half females, an approximately even distribution of respondents from various age categories, and a representative number of respondents based on the number of households in each village. The quota sampling strategy was used as a guide for the ideal number of respondents in each category, and the participants selected for each category were residents of Funafuti who were willing to participate.

A third sampling strategy sometimes employed in this research was snowball sampling. In snowball sampling, the researcher asks key individuals to name others who would be likely candidates for participation in the research. In this research, once willing participants were found in a village, the researchers would often ask those participants to suggest the names of other people living in the village who would likely want to participate as well. This strategy proved to be very effective.

On two occasions during the process of conducting interviews with community members, a minor error was made in the application of this sampling strategy. The research assistant, Merineta Kitara, was usually responsible for setting up interviews with willing participants. In two cases, a miscommunication occurred between Merineta and the
participant as they set up an interview, and the researchers ended up conducting an interview with a participant who was visiting, rather than living in Funafuti. Although this mistake was discovered in the first section of the interview, the researchers chose not to stop the interview for fear of offending the participant and losing rapport. While these two interviews provided contextual information, they were not directly included in data analysis, because the respondents did not fit the profile of the purposive sampling strategy. Therefore, although 40 community member interviews were conducted, the final sample size used in the tabulation of the results is 38.

4.2.3.2 Sample Size

Guidelines for determining nonprobabilistic sample sizes (i.e. samples that are non-random and not statistically generalizable) are virtually nonexistent (Guest et al., 2006). The size of the sample was determined based on factors that included a consideration of the tradeoff between the size of the sample and quality of data gathered, time and size of the fieldwork team, and the point of saturation.

The questions asked in this research are better suited to in-depth inquiries from a relatively small sample. Only an in-depth inquiry would enable the researchers to characterize the ways in which the people in Funafuti are vulnerable to the impacts of climate change. In addition, the sample size was limited by the fact that the fieldwork team consisted of only one university researcher and a research assistant. After considering these factors, as well as the length of the field season, a sample size of between 40 and 60 interviews was targeted. The researchers decided that the final sample size would be decided based on the point of saturation, when no new information or themes were observed in the data.
Point of saturation is highly dependant on the degree of homogeneity in the sample (Bernard, 2002, p. 161; Guest et al., 2006). In cases where research questions aim to understand common perceptions and experiences among a group of relatively homogeneous individuals, saturation can be reached in as few as twelve interviews (Guest et al., 2006). In this research, the point of saturation (i.e. the point of considerable repetition and consistency in responses) was reached at around 20 interviews, therefore, the researchers decided to stop conducting interviews at a sample size of approximately 40 (Table 4.1 and Table 4.2).

To fulfill the quota sampling strategy, as described in the previous section, it was determined that the final sample should contain approximately half males and half females, some representation across various age categories, and the number of respondents from each village should be representative of the proportion of the population of the villages. The number of respondents in each category (see Table 4.1 and Table 4.2) fulfills this objective.

Table 4.1: Description of Community Member Interview Sample by Village

<table>
<thead>
<tr>
<th>Village</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lofeagai</td>
<td>6</td>
</tr>
<tr>
<td>Teone</td>
<td>3</td>
</tr>
<tr>
<td>Fakaifou</td>
<td>6</td>
</tr>
<tr>
<td>Senala</td>
<td>4</td>
</tr>
<tr>
<td>Alapi</td>
<td>8</td>
</tr>
<tr>
<td>Vaiaku</td>
<td>5</td>
</tr>
<tr>
<td>Tekavatoetoe</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>
Table 4.2: Description of Community Member Interview Sample by Age and Sex

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>30-39</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>40-49</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>50-59</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>60-69</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>70-79</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>80-89</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19</strong></td>
<td><strong>21</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>

4.2.3.3 Interview Structure

Community member interviews were conducted using a semi-structured approach. Semi-structured interviews are a standard ethnographic technique, employed when seeking information on a topic without preconditioning responses, and used widely in indigenous (and other) communities (Bernard, 2000, p. 191; Bridges & McClatchey, 2009; Kuruppu & Liverman, 2011). This approach to interviewing involves an interview guide rather than a list of fixed questions, which affords the interviewer the flexibility to follow interesting leads (Bernard, 2000, p. 191).

The interview guide used in this research was a list of flexible, open-ended questions, grouped in themes that the interviewer covered in each interview. Table 4.3 provides a summary of the interview guide outlining the themes and sample questions. The structure of the guide followed the elements of the vulnerability approach. The first section consisted of introductory questions to become familiar with the respondent, develop rapport, and obtain contextual information. The second section aimed to develop an understanding of the conditions (social, cultural, economic, environmental, etc.) that have affected the lives and livelihoods of the respondents. At this stage, questions were left
open to invite discussion on various types of conditions, rather than prompting or limiting the focus to climatic variables. By identifying the forces that are important to respondents in an unbiased way, the role of climate can be put into the broader context of life in Funafuti. Subsequently, respondents were asked how they coped with the conditions that they identified, and those factors that constrain or enhance their ability to do so; the purpose being to develop and understanding of current adaptive capacity. The third section was designed to determine what of the anticipated climate change-related conditions affect the lives and livelihoods of respondents and in way what they do so. Again, this was followed by questions that focused on adaptive strategies to gain insight into adaptive capacity, except that it targeted the climate change-related conditions. The fourth, and final, section aimed to identify challenges that individuals perceive in the future, how these challenges would affect people, and what could be done to better address them.
<table>
<thead>
<tr>
<th>Section</th>
<th>Theme</th>
<th>Sample Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Background Information</td>
<td>How long have you lived in Funafuti? Where did you live before? Why did you move to Funafuti? Do you plan on staying in Funafuti? How many people live in your household? What do you do for a living? Are you involved in any activities/organizations in the community? How do you get food? How do you get fish? Do you have a garden? Do you have pigs?</td>
</tr>
<tr>
<td>2</td>
<td>Conditions affecting lives/livelihoods (Unprompted)</td>
<td>What do you like about living in Funafuti? What do you dislike about living in Funafuti? Is there anything that happens in Funafuti that concerns or worries you? Have you seen changes in Funafuti? How did/does/do [the conditions identified] affect you/your family? How often is it a problem? Has it always been like this? How frequently has this been happening?</td>
</tr>
<tr>
<td></td>
<td>Coping Strategies</td>
<td>How do you cope/deal with [the conditions identified]? Does this work? Have you done/did you do anything to help you cope better in the future? Why? Why not? What would make it easier to cope?</td>
</tr>
<tr>
<td>3</td>
<td>Climate change-related conditions affecting lives/livelihoods (Prompted)</td>
<td>Are you affected by [prompt with each of the climate change-related conditions, in turn]? How did/does/do these conditions affect you/your family? How often is it a problem? Has it always been like this? How frequently has this been happening?</td>
</tr>
<tr>
<td></td>
<td>Coping Strategies</td>
<td>How do you cope/deal with [the conditions identified]? Does this work? Have you done/did you do anything to help you cope better in the future? Why? Why not? What would make it easier to cope?</td>
</tr>
<tr>
<td>4</td>
<td>Future Challenges</td>
<td>Are you concerned that [the conditions discussed above] will be a problem in the future? Why? Why not? How would you respond if this problem continued/got worse in the future? What would make it easier to cope? What do you think are the main challenges facing Funafuti, looking to the future?</td>
</tr>
</tbody>
</table>
4.2.4 Key Informant Interviews

Interviews with community members were complimented with an additional 13 interviews conducted with key informants from various government departments, civil society organizations and NGOs. These interviews aimed to gain insights into the processes shaping vulnerability in Funafuti from the perspective of various experts and community leaders, and were conducted at various times before, during, and after the process of carrying out community member interviews. These interviews were also semi-structured, but the questions asked varied depending on the area of expertise of the key informant. Interviews were conducted with representatives from the MET Office, Funafuti Kaupule, the EKT Church, Disaster Risk Management Office, Red Cross, TANGO, Public Works Department, Public Health Department, Ministry of Home Affairs, Department of Education, Department of Environment, Department of Agriculture, and Fisheries Department.

4.2.5 Participant Observation

Participant observation is a method of gathering data by observing and becoming involved in community life (Bernard, 2000, p. 319). Through participant observation, the researcher gained invaluable insights, which complement and contextualize information gathered from other sources.

The researcher spent three months living in Funafuti, during which time she gained rapport with people in the community, and experienced and participated in the routines of life in Funafuti. Application of participant observation included walking around the community with community members, attending church services, participating in several afternoons of fishing, attending community feasts and gatherings, observing and participating in fatele, and experiencing a four-day round-trip visit to three of the outer
islands on the *Nivaga II*. Insights gained from participant observation were recorded in field notes, which provide a useful source of information and contribute to the main analysis, especially in that they improve the researcher’s ability to understand and interpret responses by community members. For example, by visiting the outer islands, the researcher observed how life and livelihoods in outer islands differ significantly from the relatively urban atmosphere of Funafuti. This helped the researcher better understand some of the reasons for the rural to urban migration in Tuvalu.

**4.2.6 Secondary Sources of Information**

Secondary sources of information can contribute to an understanding of risks and adaptation strategies and how these have changed over time. In addition, secondary sources can be used to establish the consistency of research findings from interviews by comparing community member accounts with other sources. Secondary sources of information including government documents, community reports, economic data, climate records, historical accounts, books and journal articles were analyzed and incorporated in the assessment of vulnerabilities.

Secondary sources were also important in characterizing future vulnerability. To characterize future exposure, a literature review of research on the ways in which climate change is expected to alter the attributes of climate that are pertinent to the community (e.g. extended dry spells, extreme sea levels, etc.) was undertaken. This information contributed to the assessment of future exposure to climate change-related risks in Funafuti.
4.3 Data Analysis

Data were analyzed using the approach described by Ford (2006). Recordings of interviews and interview notes were transcribed verbatim into a word processor following each interview. To fulfill the objectives of the research, the researcher then took several steps to retrieve information from the transcripts. Analysis of interview data was carried out using content analysis, which involves using a coding scheme to sort and retrieve information from texts based on recurring themes (Bernard, 2000, p. 456).

The coding scheme established was based upon the vulnerability framework (Ford & Smit, 2004). First, transcripts were divided into the broad categories of current exposure-sensitivities, current adaptive capacity, future exposure-sensitizes, and future adaptive capacities (see Figure 4.2). Once data was organized, the process of describing the data began.

<table>
<thead>
<tr>
<th>Current Exposure-Sensitivities</th>
<th>Future Exposure-Sensitivities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Unprompted</td>
<td>• Climate-related</td>
</tr>
<tr>
<td>• Prompted and unprompted</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current Adaptive Capacity</th>
<th>Future Adaptive Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Adaptive strategies</td>
<td>• Potential adaptive responses</td>
</tr>
<tr>
<td>• Adaptation barriers</td>
<td>• Adaptation barriers</td>
</tr>
<tr>
<td>• Adaptation opportunities</td>
<td>• Adaptation opportunities</td>
</tr>
</tbody>
</table>

**Figure 4.2:** Coding scheme developed to analyze interview data

The broad category of exposure-sensitivities was further divided into those derived from unprompted and prompted questions. Then, each transcript was read and key phrases were recorded to discover commonalities in the responses. For example, when analyzing the unprompted responses about exposure-sensitivities in the transcripts, the following sentences were read in three separate transcripts:
Now the cost of living is really expensive, it is very hard (respondent from Vaiku, age 30, September 7, 2012).

I am worried about money. Without a job, I am worried about not being able to send my kids to school (respondent from Tekavatoetoe, age 47, August 15, 2012).

[There are] opportunities issues, because... the government [of Tuvalu] spends a lot of money on education, people come highly qualified and [there are] no jobs (respondent from Alapi, age 44, October 7, 2012).

The three phrases recorded from each of these responses, respectively, were: cost of living, money worries, and limited job opportunities. Once all of the transcripts had been read, and phrases that identified exposure-sensitivities, had been recorded, the exposure-sensitivities were grouped based on commonalities. For example, the phrases above were grouped into the exposure-sensitivity that was subsequently referred to as “economy.” Analysis for the other three broad categories proceeded in a similar way.

In addition to analyzing the data to identify commonalities (i.e. unprompted and prompted exposure-sensitivities, adaptive strategies, barriers and constraints to adaptation, etc.), the data was analyzed to explain and characterize the vulnerability. This involved comparing and contrasting interviews for explanations of the drivers of exposure-sensitivities and adaptive strategies; searching for patterns of differential exposuresensitivities and adaptive capacity; and comparing with other data sources including personal observations, key informant interviews, and secondary sources.

Results from the data analysis process, are presented and discussed in Chapters 5 and 6.
CHAPTER FIVE: Current Vulnerability

This chapter presents results for two research objectives: (1) document the conditions that currently influence the lives and livelihoods of people living in Funafuti and (2) characterize the adaptive strategies employed to cope with these conditions, and the processes that have aided or constrained adaptations. This will allow for a characterization of current vulnerability to climate change in Funafuti, Tuvalu.

In the first section, conditions that affect lives and livelihoods in Funafuti (exposure-sensitivities) are identified and discussed. The second section documents and reports on current adaptation strategies being employed to cope with these exposure-sensitivities, followed by a discussion of factors that are either aiding or constraining adaptation. The third, and final, section discusses the interconnections between exposure-sensitivities and adaptive strategies and in so doing, characterizes the nature of current community vulnerability to climate change.

5.1 Exposure-Sensitivities

Most of what is written about climate change in Tuvalu focuses on biophysical impacts, especially sea-level rise. Tuvalu, in particular, has become something of a poster child for the impact of climate change. Although the impact of climate change in Tuvalu is receiving a lot of attention, few empirical studies have sought to document, from the perspective of local people, the ways in which lives and livelihoods in Tuvalu are vulnerable to the impacts of climate change. Is sea-level rise the most pressing concern for Tuvaluans, as the popular narrative suggests?
5.1.1 Unprompted Responses

Semi-structured, open-ended interviews with community members in Funafuti represent a key source of data for the research presented in this thesis. As outlined in Chapter 4, Section 4.2.3.3, *Interview Structure*, these interviews involved a set of questions that asked respondents in an unprompted manner to discuss the conditions that affected their lives and livelihoods. Table 5.1 shows the list of conditions mentioned, unprompted, by at least 4 respondents and the frequency with which each was mentioned.

**Table 5.1: Conditions Affecting Lives and Livelihoods of People Living in Funafuti, Unprompted Responses**

<table>
<thead>
<tr>
<th>Conditions Affecting Lives and Livelihoods</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>24 (63%)</td>
</tr>
<tr>
<td>Food</td>
<td>21 (55%)</td>
</tr>
<tr>
<td>Water</td>
<td>16 (42%)</td>
</tr>
<tr>
<td>Overcrowding</td>
<td>15 (42%)</td>
</tr>
<tr>
<td>Culture</td>
<td>13 (34%)</td>
</tr>
<tr>
<td>Extreme sea levels</td>
<td>11 (29%)</td>
</tr>
<tr>
<td>Coastal erosion</td>
<td>11 (29%)</td>
</tr>
<tr>
<td>Strong winds/cyclones</td>
<td>6  (16%)</td>
</tr>
<tr>
<td>Temperature</td>
<td>4   (11%)</td>
</tr>
<tr>
<td>Unpredictable weather</td>
<td>4   (11%)</td>
</tr>
</tbody>
</table>

The following sections describe the ways in which each of the conditions listed above affect the lives and livelihoods of people living in Funafuti. The information in these 10 sections summarizes the information gathered during community interviews, and reflects only the information shared by those respondents who mentioned these conditions in an unprompted manner.
5.1.1.1 Economy

Issues related to the economy, such as the transition to a cash economy, cost of living, limited job opportunities, difficulties budgeting for cultural obligations, and supporting visiting family members, were mentioned frequently by respondents as problematic conditions (Table 5.1).

The way of life in Funafuti has changed dramatically since independence. People in Funafuti do not live off their land as they did in the past, and as Tuvaluans living in outer islands, at least to some extent, still do. The traditional way of life has been replaced by a cash economy whereby homes are rented rather than built on family land, and food is bought from a store rather than harvested. As respondents described:

Ever since [Funafuti became the capital]...a person from each family has to work in order for them to get food. But before, they used to have any type of food just on their land, any Tuvaluan food, any local food. ...That’s the big difference. The people in the family had to start working because most of the people rely on food in the store (respondent from Alapi, age 71, August 14, 2012).

Life is hard. Because as you can see, nowadays, we depend on money, so you have to get a job in order for you to survive (respondent from Senala, age 78, August 1, 2012).

Many respondents referred to the cost of living in Funafuti as a problematic condition that affected their life. When asked to describe the things that made the cost of living in Funafuti so expensive, many people listed food first. Rent, and electricity were also described as being expensive. Several respondents described that the cost of living in Funafuti had been increasing in the past several years, but wages and salaries were not increasing at the same rate. One respondent stated:

The cost of living is increasing at a very high rate in comparison to the wages and salary that people are getting. When you think about it, prices of things are going right up but the increment of your salary is going up at a very slow pace so it is a concern (respondent from Vaiaku, age 32, October 8, 2012).
The transition to a cash economy has put considerable strain on people living in Funafuti where job opportunities are limited. The central government is the main employer in Funafuti, and some jobs are available through the Kaupule, the schools, the bank and small businesses. As respondents described:

The thing is the limited job opportunities. We can’t cater for everyone to have jobs because the government is the main employer (respondent from Vaiaku, age 30, September 7, 2012).

Over here, only the well educated people can get jobs – good jobs like Secretary, or whatever jobs they have in the [government] office. But for uneducated people, it is really difficult to find jobs (respondent from Alapi, age 44, September 6, 2012).

In wake of the transition from the traditional to modern lifestyle in Funafuti, a new saying has emerged in the Tuvaluan language, “[k]oe kose manafa ki laukele ako koe ko manafa ki tou poto,” meaning that before, your wealth was determined by your land, but now your wealth is determined by your intelligence. Education is now highly valued by Tuvaluans. The government spends a lot of money on funding the education system, and families recognize the importance of educating their young members to compete in the modern way of life. As a result there is an abundance of highly qualified individuals, referred to as “school-leavers,” residing in Funafuti without jobs.

The obligation to support family members in Funafuti is a source of financial stress for many respondents. It is a tradition in Tuvalu, that visiting family members will be fully supported by the hosting family, who is often the eldest member of the family. As one respondent explained:

For example, myself, if people come from the outer islands and they stay with us, we are the one responsible for everything. We have to supply food, the electricity bill and things like that. ...If people are staying in a big family, and they help each other contributing, like buying food, then they don’t have a problem. But that is the main problem here in Tuvalu. They rely. Especially, with the elders in the family, the one
who owns the place, like the house. They depend. Everything, they depend (respondent from Fakaifou, age 60, August 10, 2012).

The financial stress of this obligation is particularly problematic in Funafuti because, as the capital of Tuvalu, Funafuti draws in great numbers of visitors from outer islands. Respondents described that their family members from outer islands are drawn to Funafuti for a number of reasons including accessing the hospital for treatments, job opportunities, schooling, and even simply to spend leisure time in a relatively modern environment.

Beyond the challenge of supporting family members from outer islands, respondents cited other fakalavelave (commitments) as causes of hardship. In Funafuti, the churches, island communities, schools, and other organizations frequently embark on fundraising campaigns to which residents of Funafuti feel obligated to support. Respondents described that these fakalavelave made it very difficult to budget money in Funafuti and were thus another source of financial stress. For example, one respondent described:

[There are] a lot of gatherings, community things, and groups. Before there wasn’t. In terms of commitments, in terms of your budget, like your family budget, you plan to save this amount of money and then the next minute, the next day somebody shows up that you have to contribute this much to your community and then the next minute someone shows up and says this is a church thing you need to... Before, it wasn’t bad as it is now (respondent from Vaiaku, age 32, October 8, 2012).

5.1.1.2 Food

Food-related issues are of great concern to people living in Funafuti. Conditions such as the inability to produce, gather, and harvest local food, reliance on and cost of imported food, sickness related to unhealthy diets, and changing dietary preferences are frequently cited as problematic to lives and livelihoods (Table 5.1).
Life in Funafuti can be difficult because people tend to rely on money, rather than the land and sea to get food. Barriers to harvesting and consuming local food from the land include the inadequate space to grow food, and restricted access to land. Rapid population growth in Funafuti has caused much of the main islet to be developed with houses and buildings, and has reduced the amount of space available for growing local food. For example, one respondent described,

...Before it is good because there were few people, we had a lot of land for planting our gardens and we eat from our garden, but now because of the increasing population and the number of people here there is no space for gardening so we are forced to eat the imported foods, which requires money, which for some families is difficult (respondent from Senala, age 78, August 1, 2012).

In addition, people who are native to outer islands do not own land on which to grow and harvest local foods because they are not originally from Funafuti. As one respondent described:

Yes, especially for my case, because I’m from the outer islands so I don’t have lands. Maybe that’s the biggest problem we have, you know, we have to ask our relatives from the outer islands to give us some food instead of just having lands here. Lands here would help a lot I believe. We would have another option instead of buying foods (respondent from Vaiaku, age 30, September 7, 2012).

Harvesting fish from the sea has also become difficult in Funafuti. Fishermen have noted a decline in the number and size of the fish they are able to catch when fishing along the shore. They describe that while they used to be able to go to the ocean side and cast their net a few times to catch enough fish for a family meal, they now must walk long distances along the shore for a similar catch. As one fishermen described, “Before when you go out fishing, you can get some just at the edge, but now you have to go far” (respondent from Tekavatoetoe, age 49, August 17, 2012). Fishermen must now have access to a boat, or go diving in order to fish.
As a result of the inadequate availability of local food, people in Funafuti rely heavily on imported foods. Many respondents cite this as a problem in terms of cost, uncertain availability, and health. Many people struggle with the increasing cost of food in the shops. Imported goods are expensive because Tuvalu is so remote; however, even the cost of fish is expensive in Funafuti. For example, the cost of fish in Funafuti is AUD $4.00 or $4.50 per kilogram compared to AUD $1.00 or $2.00 in the outer islands, because in Funafuti fishermen must travel long distances in their boats to make a good catch. Also, Funafuti occasionally experiences shortages of food in the shops, which is a source of concern for some respondents. Shops in Funafuti are supplied by a cargo vessel from Fiji approximately once per month. In the past, there have been shortages of rice, flour and other goods like petrol. Finally, a number of respondents cite concerns over diet-related illness in Funafuti such as diabetes and high blood pressure. Most respondents indicate they believe that diets of imported, processed foods are responsible for increases in the incidence of these diseases.

The issues of inadequate supplies of local food and reliance on imported food are confounded by a third issue that is often discussed by respondents during interviews. Many respondents mention that food preferences, especially among young Tuvaluans, are shifting away from local foods in favour of imported foods. This creates a problem for many families struggling with the cost of living in Funafuti. For example, one respondent explains how young Tuvaluans expect rice at every meal:

...here on Funafuti, most families, they depend on buying food. And you can also see the young children seem to not enjoy eating our own traditional food... Now, they, if you go to parties or here at home, if I cook breadfruit and a pot of rice, the pot of rice will just disappear, but you will have so many breadfruit leftovers. But the rice no, you cook rice in the afternoon, you cook rice in the evening, you cook rice again in the morning. That’s what we are experiencing now... That’s what they are
expecting, they just want rice, nothing else (respondent from Fakaifou, August 22, 2012).

5.1.1.3 Water

Community member interviews for this research began less than one year after the Government of Tuvalu declared a state of emergency because stores of freshwater were depleted to dangerously low levels in Funafuti and the outer islands, after several months of less than average rainfall. This experience was still fresh in the minds of the respondents who participated in this research. Many respondents cited water shortage as a major problem affecting life in Funafuti (Table 5.1).

Taula (dry spells) are not uncommon during the dry season from April to October in Funafuti. A dry spell as short as one or two weeks can cause water stress for some families. Most respondents report that the drought in 2011 is the worst drought in memory because it lasted longer, and was more severe than any other. During the 2011 drought, families did not have enough water for drinking, bathing, cooking, washing, or feeding their pigs. Trees died. so fewer resources from the land were available, pulaka pits withered, and gardens were abandoned in order to conserve fresh water.

Respondents see the water problem in Funafuti as a function of water storage capacity and number of people per household. Respondents tend to state that they either really suffered, or that they were able to manage fairly well depending on the number of people in their household. For example, one respondent stated:

We were really concerned about the last drought because we really faced a lot of problems because we had a lot of family members at the time (respondent from Teone, age 26, August 13, 2012).

While another said:
The drought didn’t really affect us much because we have enough water tanks and, our family, there are only a few of us, four of us, so we have to ration our water wisely and use it wisely. But, nevertheless, we still had to get our water from the island community tanks, our ration (respondent from Fakaifou, age 60, August 10, 2012).

Funafuti receives approximately 3500mm of rainfall per year, which is usually adequate to serve the population’s freshwater needs. Since Funafuti receives such a large amount of rainfall, locals also view the water issue as a problem of inadequate water storage capacity. As an elder in Funafuti described, “…we’ve got plenty of rain but the problem is the water storage, it is not enough” (respondent from Alapi, age 72, September 10, 2012).

Dry spells are viewed as particularly challenging to manage in Funafuti compared to the outer islands, and compared to the past. Dry spells are considered particularly problematic in Funafuti because, unlike the outer islands, Funafuti does not have a viable freshwater lens. For example, one respondent stated, “Over here [taula] is really difficult because there is not enough water, but where we come from in our home island, we have water from the well” (respondent from Fakaifou, age 66, August 7, 2012). Also, in the past, dry spells in Funafuti were not as challenging because there were fewer people, people used to use seawater rather than freshwater for many household activities, and people used to drink coconut juice in times of need. Today, the demand for freshwater is higher because of the increased population, and changes in water use behaviour. In addition, some of the traditional water management strategies such as the preparation of dried fish and the drinking of coconut juice are not practiced as they once were.
5.1.1.4 Overcrowding

Overcrowding is a term used frequently by respondents when discussing conditions affecting lives and livelihoods in Funafuti (Table 5.1). The growing population of Funafuti is linked to a variety of issues including some of the food-related and economic conditions discussed in previous sections. Overcrowding is an issue at both the island scale and the household scale.

At the island scale, several respondents discussed the link between the increasing population in Funafuti and the fact that there was less land available to grow and harvest local foods. For example, one respondent stated:

Before, most of the people living on the island, they eat local food. But nowadays, it has changed; they eat local food from the store. ...There is not enough land to plant crops because most of the people they stay on it. So [we] don’t have enough space to build [our] gardens or any crops for [our]selves (respondent from Alapi, age 71, August 14, 2012).

Other respondents discuss concerns over the amount of building occurring on Funafuti to accommodate the increasing population. They are concerned because buildings are rapidly consuming the land in Funafuti, because they are now living in close proximity to their neighbours, and because the concrete required to construct homes in Funafuti is made of stones and sand taken from the coastline, which has implications for land rights and coastal erosion.

An indigenous Funafuti elder also described that she was concerned about overcrowding in Funafuti because now, she doesn’t have enough land to pass on to her children. The government now leases most of it, and has built upon it. In the respondent’s words, “A family should have enough land [as a] foundation for the children. But it is not enough now because all the land is used. So there is not enough land for the children”
(respondent from Alapi, age 71, August 14, 2012). The respondent then went on to quote, “fikjoe kose manafa ki lauкеle ako koe ko manafa ki tou poto,” meaning that before, your wealth was determined by your land, but now your wealth is determined by your intelligence. People living in Funafuti can no longer rely on their land as the foundation of their livelihood.

Many respondents expressed frustration over the number of people residing in Funafuti for no apparent reason. Unemployment was viewed as an issue, not only by the unemployed, but by other residents who were concerned about the poor living conditions of some families in Tuvalu, the number of school aged children whose parents could not afford to send them to school, the number of youth without jobs to occupy their time, and the number of financially stressed people who might resort to stealing in order to meet their needs.

Overcrowding is also an issue at the household scale. As discussed earlier, many families in Funafuti experience financial stress as a result of supporting family members who are visiting or have moved from outer islands. It is not uncommon in Funafuti to have several families residing in the same home with only one or two working members financially supporting a large number of individuals.

In one extreme example, a respondent described that between 30 and 40 people were living in her house. The house belonged to her and her husband, but there were four other couples also living there with their children, plus a few single boys who had graduated from Atamu, the seafaring school, and were waiting for work, plus one young girl whose parents had asked if she could reside with them in Funafuti to attend the Nauti Primary School rather than attend the school on her home island. The people residing
with them were close relatives on both her side and her husband's side, although mostly from her husband's side, and although sometimes the single working boys would contribute by buying a bag of rice or sugar, it was mostly she and her husband supporting the entire household. As she described:

It is so difficult. Even if there are only two people working in the families and you have to support all 40 mouths. Usually that's what I'm doing here in our place we cook for everybody. And even for the food, some of them... my boys that are working, they can help out, like buying a bag or rice or some sugar just to help out for the next two weeks. But it's mostly me and my husband (respondent from Fakaifou, August 22, 2012).

Overcrowding at the household level poses more than just a financial burden to families. Respondents also indicated that overcrowded homes were more prone to water shortage and illness.

5.1.1.5 Culture

There are a number of conditions related to Tuvaluan culture that respondents discussed as having an impact on lives and livelihoods in Funafuti. As in the previous section on overcrowding, there is some overlap in the issues discussed in this section with those discussed in previous sections. Supporting family members from outer islands, *fakalavelave*, declining social cohesion, changing lifestyle, and changing traditional knowledge are issues related to culture that many respondents identified as affecting lives and livelihoods in Funafuti (Table 5.1).

The challenge of supporting family members from outer islands represents a financial burden, related to overcrowding at the household level, but it is best understood in the context of Tuvaluan culture whereby family members are obligated to support their family, even at the expense of their personal well-being. Similarly, *fakalavelave* represent a financial burden, but are best understood in the context of Tuvaluan culture. In both cases,
respondents expressed a cultural obligation to support their extended family and to contribute to various fundraising activities, even when it was not in their personal best interest. For example, when discussing the obligation to support family members from outer islands, one respondent said, “It’s tradition. You can’t say no you can’t come. It’s very... It is bad” (respondent from Fakaifou, age 60, August 10, 2012). Another respondent, when describing fakalavelave, said:

There are so many commitments here on the capital. We have church fundraisings, islands fundraisings, even school fundraisings, there are so many fundraisings that we need to contribute to and it is a must that we should give. They expect it. Those commitments, like the church, it is hard for us not to donate, it is a must that we donate (respondent from Fakaifou, age 50, August 22, 2012).

In contrast to the challenges posed by these cultural obligations, some respondents expressed concern about an opposing phenomenon; declining social cohesion, manifested as resistance to the Tuvaluan culture of communal living and sharing. For example, one Funafuti elder described that the Funafuti community is facing difficulties getting community members to contribute to community activities:

I am talking on the problems that our community is facing. Firstly, when they are asked to contribute to the activity... they are not contributing to our fundraising or other activities. And, when we ask them to come and do a job, they’ll ask for money, they will only work if they get paid. But, because it is community work we normally, you know, you go and work, no pay (respondent from Alapi, age 72, September 10, 2012).

Another respondent commented on the fact that people in Funafuti are less willing to share local food from the land than they were in the past. She said:

It’s different from before. Before, you just go and ask, but now, it is embarrassing to go and do that. It is only if somebody is closely related to you. But, I remember that in the past, people say come and get it, like... we’ve got a lot so come and get it, but now they are expecting sort of like a barter system or exchange. Like, [if we ask], “can we get some breadfruit?,” then they expect a packet of 2kg or 4kg of rice (respondent from Fakaifou, age 50, August 22, 2012).
The modernization of Funafuti and corresponding changes in the way of life are mentioned by many respondents as conditions that have affected lives and livelihoods. Some changes such as the construction of the tar sealed road, the widespread use of motorbikes and the building of concrete homes are viewed as beneficial changes, while others expressed a sense of loss for the intrinsic value of the traditional way of life. As one respondent described:

We are starting to adopt the European style of living. We don’t really rely on our own resources instead but we depend on mostly on imports from overseas. Culture-wise, I think we have lost a lot of our traditions, the traditional values we used to have. And I think for our generation we’ve really, I think there is a really big barrier between us and what our grandparents knew about traditions and culture (respondent from Vaiaku, age 30, September 7, 2012).

As described earlier, other respondents discussed that the transition to the cash economy, and the transition from the local food system to the reliance on imported food are problematic for people living in Funafuti.

One respondent, an elder in Funafuti, described the traditional wisdom of the fishermen (mulivaka) has recently changed as a result of climatic change. He said:

The changes of climate, also affect the knowledge of the wise man because in the olden days it is easy to tell the good times to go out fishing, but now it has changed. For example, it is easy to know that right now it is a good time to get fish so you get the fish right away. It is hard for other people to know, except the wise man. Some people will go, will use how many gallons of petrol and they can’t catch any fish (respondent from Fakaifou, age 87, August 30, 2012).

5.1.1.6 Extreme sea levels

Some respondents identified extreme sea levels as a condition affecting lives and livelihoods in Funafuti (Table 5.1). Widespread flooding in certain areas of Funafuti during king tide events, and salt water intrusion of pulaka pits and gardens are problematic conditions associated with extreme sea levels.
During extreme high tide events, the most widespread impacts result, not from inundation of seawater from the coasts, but rather from the bubbling-up of seawater through the atoll’s porous coralline soil. The bubbling-up of seawater through the soil occurs in low-lying areas of Fongafale Islet (i.e. in the former taisala areas surrounding the airstrip and the Nui maneapa, and the burrow pits) whenever there is a high tide above 3m.

Some respondents recall king tide events that cause widespread flooding in certain parts of Funafuti. The affected areas in the past have been the low-lying, former taisala areas where Fakaifou is established, and the narrow strips of land on either end of the islet, which includes Teone, Lofeagai, and Tekavatoetoe. In the past, some households in Fakaifou have been evacuated. One respondent recalls a king tide event she witnessed in the last decade:

When we had the king tide event the island was... really flooded to the government had to evacuate people from their homes. It was really flooded and the airstrip was all covered with sea. And that side [the ocean side], they said that the waves really landed on the land... I think it went inside the Nui maneapa, and people were swimming and paddling canoes on the road. At that time I was with some Japanese people, they came here to take some photos. We had those minivans and we had to drive them through the waters. This part [the central part near Alapi and the Government Building] didn't get affected but the airstrip was all covered with water (respondent from Alapi, age 44, September 6, 2012).

The maneapa belonging to the Nui island community was frequently mentioned as a site where flooding due to high tides was a concern. During the fieldwork for this research, a high tide above 3m occurred in mid-October and the researcher witnessed the type of flooding that occurs when seawater bubbles up through the soil. As depicted in Figure 5.3, the Nui maneapa is prone to flooding during tidal events above 3m, because it is located in, what was once a taisala.
Figure 5.1: Nui *maneapa* surrounded by high water during a tide above 3m in October 2012

The burrow pits in Funafuti also tend to fill during high tide events, which is a problem for people living nearby. The burrow pits in Funafuti are filled with rubbish that moves with the tides, and in some places, there is only a narrow footpath on which people can walk to access their homes (see Figure 5.2 for a comparison normal tide and high tide).
Figure 5.2: Above left: Squatter settlement surrounding burrow pit in Teone at normal tide. Above right: The same area during a tide above 3m in October 2012, showing flooding of the narrow footpath.

One respondent living beside the burrow pit in Teone said:

...When it comes to king tide or spring tide the water is sometimes up to your ankle. Sometimes it is, you know this pond, they have bacteria in it because all this rubbish has been dumped into the pond. So it’s like a risk walking in this footpath when it’s high tide (respondent from Teone, age 37, August 13, 2012).

People living in Funafuti who had tried to maintain a garden or *pulaka* pit expressed that their crops suffered from salt water intrusion, and that salt water intrusion events were becoming more frequent. This has caused many people to abandon their gardens and *pulaka* pits. One respondent described:

It affects my life because we used to eat taro, but now salt water is coming up and it is very hard to grow. Some still work [in their gardens] but it is very hard. Maybe 5 years ago, I stopped gardening (respondent from Alapi, age 54, August 23, 2012).

5.1.1.7 Coastal erosion

Several respondents indicate coastal erosion is a condition affecting lives and livelihoods in Funafuti (Table 5.1). These respondents were noticing changes in the shorelines and expressed that they were worried about the potential future implications of these changes, and that landowners and people living near the coast were currently being
affected. Also, as mentioned in Section 5.1.1.4, *Overcrowding*, some respondents are
concerned about coastal erosion being driven by the taking of stones and gravel from the
coastline in order to produce cement for building projects.

Many respondents use the phrase, “the land is being eaten by the sea” to describe
what they are witnessing. Some say that Funafuti is more narrow than they remember, and
the beaches are not as wide as they once were. Many respondents noted the loss of trees
along the shores, especially in Lofeagai. As one respondent described:

> When I first came here the beach is further our there on the lagoon side, and the
same on the ocean side. Now when you go and stand on the main road there, it is
about 2 or 3 metres to the beach [on the lagoon side]. The sea comes up as far as
that or even comes to the road, but before it was further out. All the trees have been
falling. The same as on this side [the ocean side]. The ground here before was
further out about 3-4 metres now have been washed away from where it was before
(from Lofeagai, age 69, September 10, 2012).

When asked about if these changes were affecting the lives and livelihoods of people in
Funafuti, this respondent replied:

> The people themselves in their homes, they are still safe because they don’t build
their houses very close to the beaches. But as you see from that side [Tekavatoetoeto],
there is very little ground left now for the homes of the people, they are very close
now to the beach.

> It was common for respondents to describe that they were witnessing coastal
erosion in Funafuti, but to describe only worry and impacts on other people’s lives.

Examples of this include:

> For the people who live close by [the sea], it really affects them. People living in the
interior of the island I don’t think they see it that way (respondent from Vaiaku, age
32, October 8, 2012).

> [Coastal erosion] affects me because it makes me scared. You know, will it eat all
the land, or just that certain spot? But from the look of it, it’s sort of eating the
whole land... Us, we live in the middle, unlike other people who live near the beach...
I think they are affected, but we haven’t experienced that because our house is in the
middle of the island (respondent from Vaiaku, age 21, July 26, 2012).
Some respondents described that the impact of coastal erosion on the outer islets was worse than what they could see on Fongafale Islet. This is particularly problematic for the indigenous Funafuti people who own land on the outer islets. Boundary disputes have occurred in cases where landowners have lost significant portions of their land and have attempted to acquire more land to replace what they have lost. The lands court has dealt with these disputes. One respondent also described that erosion of islet shorelines was often accompanied by accretion on another section of the shoreline. For example, a Funafuti elder described:

It really affects the outer islets, the small islets. When people go out to look at their land, a big part of their land has been washed away... That's the problem. Especially on the small islets, they are not good... But then other people's lands have been extended into the ocean because it has been taken from the other side (respondent from Alapi, age 72, September 10, 2012).

Another issue raised in discussions of coastal erosion was that of the taking of sand and gravel from the shores of Funafuti. Respondents recognized that a great quantity of material was being taken from the shores to make concrete needed for construction projects in Funafuti. Some respondents expressed that they were unsure whether the coastal erosion they were witnessing in some places was due to natural causes associated with climate change, or the taking of stones and gravel. For example, one respondent said:

...People are building their houses and they are getting the sand and the stone and the gravels from our land and that's our concern because... Funafuti is not very big. It is a narrow strip of land and these people are getting the sand, stones and their land is getting small because they are taking part of the beach or the ocean side (respondent from Alapi, age 72, September 10, 2012).

5.1.1.8 Strong winds and cyclones

Six respondents identified strong winds and cyclones as conditions affecting lives and livelihoods in Funafuti (Table 5.1). Four respondents recalled the impacts of Hurricane
Bebe in 1972, and the other two described that strong winds can spoil gardens and damage trees or cause tress to fall on homes.

Tropical cyclones occasionally begin to develop close to Tuvalu, but it is rare for Tuvalu to suffer a direct hit from a hurricane. Funafuti has been affected by major tropical cyclones in the past that have caused serious damage. Particularly notable was the December 1883 hurricane (McLean & Hosking, 1992), and more recently Hurricane Bebe in October 1972 that resulted in the overnight formation of a massive rubble rampart along the eastern coastline of Funafuti (Maragos et al., 1973). Respondents who had lived in Funafuti in 1972 when Hurricane Bebe struck, spoke of the extreme damage the cyclone had caused to homes, trees and gardens.

A direct hit from a hurricane is a rare event in Funafuti; however, strong winds are a much more frequent occurrence affecting lives and livelihoods. Very strong winds can damage trees and spoil gardens. One respondent described:

We used to have a garden on the other side of our house but the problem is because of the strong wind warning, it damages the food crops and stuff. Getting them on the other side [of the house] is hard because it is exposed to everybody, it is not safe [from people who might steal the food]. The last time we had a garden, it was a big one, there was a very strong wind and it blew the garden, everything just went poof. It was heavy rain and... That was, last year or the year before (respondent from Vaiaku, age 32, October 8, 2012).

There is also widespread fear in Funafuti of coconut trees falling on houses during strong winds. One respondent described:

I am worried that the coconut tree will fall on my house and destroy it. [During strong winds] it is hard for us to move around to another house or to go to our neighbours in the middle of the island. We just have to stay in our house because it is not safe to leave (respondent from Lofeagai, age 43, August 2, 2012).
5.1.1.9 Temperature

Respondents reported that the temperature in Funafuti was becoming hotter over time, and that the heat was becoming unpleasant. Some respondents described that Funafuti feels much hotter compared to the past and compared to the outer islands because there is much less canopy cover. For example:

I’ve noticed it is really hot here in Funafuti compared to the [outer] islands. I think it is because they have cut down the trees because of settlement and people building houses. They clear this area but then you know, this small portion of area contributes so much to the whole island because it is so small. So it is getting hotter and hotter (respondent from Va’iaku, age 32, October 8, 2012);

Before it is not as hot as nowadays. It is like burning, it’s just like sitting beside a fire. In those days, it’s nice, shady, it was hot but not nearly as hot as nowadays (respondent from Alapi, age 44, September 6, 2012).

5.1.1.10 Unpredictable weather

Some respondents report that they have recently been noticing unseasonal weather in Funafuti, which has implications for planning with respect to water use, and the timing of activities like fishing. Typically, Funafuti experiences dry, good weather, characterized by easterly trade winds between April and October, and wet, stormy weather, characterized by westerly winds between November and March. However, some respondents have noted that strong winds, dry spells and wet weather have been occurring outside of these normal seasonal patterns. For example:

... Before in Funafuti, normally we have windy times (November, December, January) but now it is anytime. Raining and windy. Sort of like seasons. Our seasons we have windy times those are the bad weather times. That’s before. But now, the last few years ... the weather is anytime (respondent from Te’akavatoeto’o, age 53, August 17, 2012);

Last week [second week of August, 2012] we have a strong wind warning and that’s unusual for this time of year. In the past there is only strong winds from October to April (respondent from Alapi, age 54, August 23, 2012).
Last year with that drought... and this year, too much rain. It is inconsistent so... if you’re planning revolving around climate and stuff it is a bit hard to plan (respondent from Alapi, age 44, October 7, 2012).

5.1.2 Prompted Responses

The line of unprompted questioning in interviews with community members was followed by a second line of prompted questioning (Table 4.3). Respondents were prompted to discuss whether the predicated impacts of climate change were stressing their lives and livelihoods. For the most part, when respondents were prompted to discuss whether their lives and livelihoods were affected by specific conditions, they gave similar responses to those respondents who identified the conditions unprompted (if they were affected by the prompted condition). Any additional insights regarding the conditions affecting lives and livelihoods in Funafuti listed in Table 5.1 gained in the prompted line of questioning are included in Section 5.3, Current Vulnerability to Climate Change. One condition, frequently cited during the prompted line of questioning, but never mentioned during the unprompted portion of the interview was that of ciguatera poisoning.

Ciguatera fish poisoning arises when people consume coral reef fish that have been contaminated by ciguatoxins. Ciguatoxins are produced by plankton called dinoflagellates (particularly Gambierdiscus toxicus), which live on the surfaces of seaweeds (Hales et al., 1999; Llewellyn, 2010; Skinner et al., 2011). Ciguatoxins bioaccumulate up the food chain as herbivorous reef fish become contaminated when feeding on seaweed, and when herbivorous fish are preyed on by carnivorous fish (Hales et al., 1999; Llewellyn, 2010; Skinner et al., 2011). After consuming fish contaminated with ciguatoxin, people experience potentially severe acute neurologic, gastrointestinal, and cardiac symptoms,
and in some cases, chronic neurological symptoms lasting weeks to months (Skinner et al., 2011).

Although respondents never mention ciguatera fish poisoning as a condition that affected their life in Funafuti, when prompted to discuss any changes or problems they had encountered with the fish they were harvesting or consuming, many discussed ciguatera incidence. Importantly, the degree to which ciguatera was mentioned by respondents is, in part, a reflection of the fact there was an outbreak of ciguatera in Funafuti while the fieldwork for this research was ongoing.

While a couple of respondents had close family members who had been affected by ciguatera poisonings, most respondents were simply aware of an outbreak through radio announcements. Many respondents expressed surprise at the species of fish that were listed as contaminated. Certain fish in Funafuti are known to be especially prone to ciguatoxins and these are usually avoided. The outbreak in late July to August 2012 affected several species of fish that are usually considered safe.

Respondents were inconsistent in their reporting of whether ciguatera outbreaks were more common now than in the past. Most respondents indicated that ciguatera incidence was more common now than in the past but in many cases it seemed as though the current outbreak was the primary reason for making such a statement.

5.2 Adaptive Strategies and Capacity

5.2.1 Adaptive Strategies

Tuvaluans employ a wide range of adaptive responses to cope with the various exposure-sensitivities they experience. This section explores how community members have responded, and are currently responding to the exposures identified in the previous
This section draws on insights gained from the responses to the unprompted and prompted lines of questioning in the community interviews.

Table 5.2 outlines adaptation strategies employed by community members in response to exposure-sensitivities. This is followed by a characterization of the different types of adaptive responses that emerge from an analysis of adaptation strategies employed in Funafuti to cope with exposure-sensitivities.
<table>
<thead>
<tr>
<th>Exposure-Sensitivity</th>
<th>Adaptive Strategies</th>
<th>Additional Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>• Get an education to get a job to make money&lt;br&gt;• Get a small job or make handicrafts</td>
<td>• Migrate to Fiji, New Zealand or Australia to seek opportunities&lt;br&gt;• Remittances from family members overseas</td>
</tr>
<tr>
<td>Food</td>
<td>• Buy food from the shops&lt;br&gt;• Go fishing&lt;br&gt;• Ask for and receive food from relatives in outer islands</td>
<td>• Get an education to get a job to make money&lt;br&gt;• Get a job or make handicrafts</td>
</tr>
<tr>
<td>Water</td>
<td>• Ration water&lt;br&gt;• Conserve water&lt;br&gt;• Use seawater (e.g. for bathing, washing clothes and dishes, flushing the toilet)&lt;br&gt;• Use well water (e.g. for bathing, washing clothes and dishes, flushing the toilet, give to the pigs)&lt;br&gt;• Get water from the community hall&lt;br&gt;• Borrow from neighbours&lt;br&gt;• Buy water from the government&lt;br&gt;• Let crops die</td>
<td>• Slaughter pigs&lt;br&gt;• Recycle grey water (e.g. give to pigs water used to wash rice, use dirty water from washing to flush toilet)&lt;br&gt;• Get desalinated water from the government&lt;br&gt;• Install composting toilet&lt;br&gt;• Buy bottled water&lt;br&gt;• Collect water from leaky gutters in buckets when it rains&lt;br&gt;• Get more tanks&lt;br&gt;• Buy more tanks</td>
</tr>
<tr>
<td>Overcrowding</td>
<td>• Do nothing&lt;br&gt;• Ask for and receive food from relatives in outer islands</td>
<td>• Get an education to get a job to make money&lt;br&gt;• Import stones and gravel from Fiji</td>
</tr>
<tr>
<td>Culture</td>
<td>• Do nothing&lt;br&gt;• Remittances from family members overseas</td>
<td>• Get an education to get a job to make money&lt;br&gt;• Get a job or make handicrafts</td>
</tr>
<tr>
<td>Extreme sea levels</td>
<td>• Shift location of house&lt;br&gt;• Construct sea-walls&lt;br&gt;• Harvest crops or let crops die, and replant later&lt;br&gt;• Relocate crops&lt;br&gt;• Abandon crops&lt;br&gt;• Elevate gardens</td>
<td>• Build wall to protect gardens&lt;br&gt;• Do nothing&lt;br&gt;• Evacuate to unaffected areas&lt;br&gt;• Donor-sponsored sea-wall construction&lt;br&gt;• Put faith in God</td>
</tr>
<tr>
<td>Coastal Erosion</td>
<td>• Acceptance&lt;br&gt;• Go to lands court to fight for more lands&lt;br&gt;• Construct sea walls&lt;br&gt;• Throw rubbish along coast for coastal protection&lt;br&gt;• Government-led planting of trees near the coast</td>
<td>• Collect rocks to make piles of stones&lt;br&gt;• Import stones and gravel from Fiji&lt;br&gt;• Do nothing&lt;br&gt;• Put faith in God</td>
</tr>
<tr>
<td>Strong winds and cyclones</td>
<td>• Tie umu to trees with ropes&lt;br&gt;• Stay indoors&lt;br&gt;• Build a local wall to break the wind</td>
<td>• Cut coconut trees near houses&lt;br&gt;• Do nothing</td>
</tr>
<tr>
<td>Temperature</td>
<td>• Do nothing</td>
<td></td>
</tr>
<tr>
<td>Unpredictable weather</td>
<td>• Do nothing</td>
<td></td>
</tr>
<tr>
<td>Ciguatera Fish poisoning</td>
<td>• Listen to the radio, and avoid fish announced as poisonous and eat deep-sea fish, or avoid all fish</td>
<td>• Some species of reef fish are always avoided</td>
</tr>
</tbody>
</table>
Table 5.2 reveals the great variety of measures or actions that are taken in Funafuti to adapt to conditions affecting lives and livelihoods. There exist numerous characteristics by which adaptations can be distinguished, and a variety of frameworks for systematically defining adaptations (Burton et al. 1993; Carter et al., 1994; Smithers & Smit, 1997; Smit et al., 1999; Smit & Skinner, 2002; Wheaton & MacIver, 1999). For example, Burton et al. (1993) described that human adjustments to natural hazards can be separated based on purposefulness (i.e. those are purposefully adopted and those that are incidental), and then further characterized based on function (i.e. those that involve choosing change, reducing loses, or accepting loses). Smit et al. (1999) summarize some of the common attributes used to differentiate adaptation processes and forms, including purposefulness (e.g. autonomous or planned), timing (e.g. anticipatory or responsive), temporal scope (e.g. short term or long term), spatial scope (e.g. localized or widespread), function (e.g. prevent, tolerate, etc.), form (e.g. structural, legal, etc.), and performance (e.g. effectiveness, equity, etc.).

With the various attributes for characterizing adaptations in mind, an analysis of the adaptation data reveals eight processes by which adaptive strategies in Funafuti can be characterized. These processes are: bear the effects; reactive, short-term behaviour change; rely on the market; rely on traditional knowledge and activities; share the burden; rely on aid or government intervention; change locations to reduce exposure; and, modify surroundings to reduce exposure. Each of these processes of adaptation will be described with the use of examples in the following sections.
5.2.1.1 Bear

Bearing refers to the process through which individuals experience the effects of exposure-sensitivities without attempting to modify the exposure-sensitivity or enhance their capacity to cope with the exposure (e.g. doing nothing, accepting loss, and putting faith in God). Bearing the effects of exposure-sensitivities is an adaptive strategy employed widely in Funafuti. People in Funafuti bear the financial burden of cultural commitments, overcrowding, loss of land due to coastal erosion, and the loss of crops due to salt-water intrusion. Bearing the effects is the response employed for impacts that people in Funafuti view as inevitable and feel helpless against.

5.2.1.2 Reactive, Short-term Behaviour Changes

Reactive, short-term behaviour changes refer to actions taken by individuals in response to acute conditions (e.g. drought or ciguatera fish poisoning outbreak) that affect their livelihoods. During a period of drought in Funafuti, for example, people change their pattern of water use and demand compared to other times of the year. They ration the water from their household tanks, conserve water, recycle grey water, slaughter pigs and abandon crops to reduce water demand, use sea water and well water for tasks such as washing and bathing, and feverishly collect rain water from leaky gutters whenever it rains. Also, during a ciguatera outbreak in Funafuti, people listen to the radio to learn about the types of fish that are contaminated and avoid eating these species. Reactive, short-term behaviour changes are acted out in response to acute conditions, and are abandoned when the conditions have passed. Hence, they do not change inherent vulnerability to the condition should it recur.
5.2.1.3 Rely on the Market

Relying on the market has emerged as a process through which adaptation is possible in Funafuti as a result of the shift toward commercialization and a cash economy. The act of purchasing goods, such as water (sold and delivered by the government from a large cistern located underneath the Government Building), water tanks, and food is a way of decreasing sensitivity to exposures and increasing adaptive capacity. People in Funafuti also view the act of getting an education for the purpose of securing a job to make money, and the act of getting a small job such as the making and selling of handicrafts, as critical adaptive strategies in modern Funafuti.

5.2.1.4 Traditional Knowledge and Activities

Relying on traditional knowledge as an adaptive strategy refers to the process through which individuals use traditional knowledge about the environment in Funafuti to reduce exposure-sensitivity. For example, fishermen always avoid some species of reef fish because they are known to frequently be contaminated with ciguatera toxin. In this sense, avoiding certain fish species represents a proactive adaptation that functions to reduce exposure-sensitivity to ciguatera fish poisoning.

A related adaptive strategy is that of turning to traditional activities to reduce exposure-sensitivity and increase adaptive capacity. For example, fishing is an activity that is considered an integral part of traditional Tuvaluan culture. Today, fishing is not central to the lives of most people in Funafuti; however, some people view fishing as a way of coping with the high cost of store-bought food.
5.2.1.5 Share

Sharing refers to the process through which individuals and families cope with the effects of exposure-sensitivities by sharing the burden and enhancing adaptive capacity. Sharing the effects of exposure-sensitivities is an adaptive strategy employed widely in Funafuti and across Tuvalu. This is largely a reflection of the collectivist nature of Tuvaluan society. Sharing networks in Funafuti extend between neighbours, among island community groups, among relatives living nearby, on outer islands, and overseas. Sharing the burden of exposure-sensitivities is a strategy used in response to water shortage, local food shortage, economic hardship, and poverty of opportunity.

When discussing the ways in which her family coped during the extreme drought in 2011, one respondent described, “Tuvalu is nice because you know, people they share, if you know what I mean. Everyone, they just help each other” (respondent from Vaiaku, age 21, July 26, 2012).

During water shortage events, neighbours with plenty of water commonly share with those who have little. Sharing of water is also common among island communities. Since each island community has a maneapa with a water tank or cistern, families often ask their island community for permission to take water from the communal water storage when water is scarce.

Sharing of food among families is also common, especially the sharing of local foods from outer islands. Almost all families in Funafuti receive some local foods from relatives living in the outer islands. Although exchange is informal, it is common for employed people in Funafuti to remit money to their relatives living in the outer islands. Remittances are also very common in Funafuti from family members living overseas.
5.2.1.6 Aid and Government Intervention

As an adaptive strategy, aid and government intervention refers to the process through which external agencies, rather than individuals, play a role in modifying exposure-sensitivities or enhancing adaptive capacity in Funafuti. Aid and government intervention are involved in promoting adaptation with respect to a variety of conditions affecting lives and livelihoods in Funafuti including water shortage, economic hardship, extreme sea levels, and coastal erosion.

For example, as described in Section 3.2.3.3, Water Harvesting System, exposure-sensitivity to water shortage in Tuvalu has drawn a great deal of attention from international aid donors in recent years. In addition to extensive international assistance in the water sector, Tuvalu receives aid in the form of single donations and long-term capacity building projects in a variety of sectors. For example, during the fieldwork portion of this research, a shipment of 130 tonnes of packaged rice arrived in Funafuti from the Embassy of the Russian Federation in Australia “in order to help Tuvalu to address the challenges of economic development” (Embassy of the Russian Federation in Australia, 2012).

These interventions have significantly altered the adaptation landscape in Funafuti, not only in the ways that they have reduced vulnerability to various stressors (e.g. water tank donations to households to alleviate water stress, and rice donations to alleviate food expenses), but also because individuals now rely on aid and governments to deal with stresses rather than responding to stresses on their own. When asked about coping mechanisms employed for various exposure-sensitivities, it was not uncommon to hear a
response such as, “Nowadays, we can look to the big countries, and we can ask them for help” (respondent from Fakaifou, age 87, August 30, 2012).

5.2.1.7 Change of Location to Reduce Exposure

Changing location to reduce exposure refers to the process through which individuals or families move themselves or components of their livelihoods to different locations to reduce or eliminate exposure to a condition that affects them. Changes in location can involve modest distances or international migration, and can be permanent or short-term. For example, in response to the flooding that occasionally results from very high tide events, two respondents reported shifting the location of their homes several meters inland. This represents a permanent change of location, and a modest distance. Alternatively, some respondents reported evacuating their homes prone to flooding during high tide events (e.g. in Lofeagai) into the centre of Funafuti to live with relatives for short time. This represents a temporary change of location, and again, a modest distance. Yet another alternative that some families discussed, is migrating overseas. Presently, the primary motivation for international migration from Funafuti is to escape the poverty of opportunity in Tuvalu. This represents a permanent or temporary change of location at a great distance.

Changing location to reduce exposure as an adaptive strategy is not limited to place of residence. Some people in Funafuti also described relocating their crops to a location that was less prone to salt-water intrusion during high tide events.

5.2.1.8 Modify Surroundings to Reduce Exposure

Modifying surroundings to reduce exposure refers to the process through which individuals prevent the injurious effects of an exposure-sensitivity. Constructing coastal
barriers to prevent flooding and erosion, elevating crops to evade salt water intrusion, erecting local walls to break strong winds, and cutting coconut trees near houses to prevent the damage of fallen trees during strong wind events are some of the ways in which this adaptive response manifests. Modifying surroundings to reduce exposure is not employed as widely as some of the other adaptive strategies.

5.2.2 Barriers to, and Opportunities for Adaptation

Understanding factors that influence or constrain a system’s adaptive capacity are useful when considering the adaptive potential, or adaptive capacity, of a system. Though a potential adaptive option may be feasible, community members must have the necessary capacity to be able to employ that strategy. Adaptive capacity is influenced by economic wealth, social networks, institutions and capital, experience with previous risk, equity of access to resources within the community, infrastructure, the range of technological adaptation available, as well as by other stresses that contribute to the environment in which decisions are made (Adger, 2003; Ford and Smit, 2004; Yohe and Tol, 2002). Many of the determinants that aid or constrain a system’s adaptive capacity are similar to those that influence its sensitivity (Smit & Wandel, 2006). In Funafuti, a variety of factors act as barriers to adaptation, while other processes represent opportunities for adaptation (Table 5.3). This section will explore the barriers to, and opportunities for adaptation that arise from an analysis of the data on adaptation strategies.
Table 5.3 Opportunities and Barriers for Adaptation in Funafuti

<table>
<thead>
<tr>
<th>Barriers</th>
<th>Opportunities</th>
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<tbody>
<tr>
<td>Smallness and isolation</td>
<td>Radio communication</td>
</tr>
<tr>
<td>High cost of living &amp; few jobs, low wages</td>
<td>Social capital</td>
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<tr>
<td>Overcrowding</td>
<td>Traditional knowledge and activities</td>
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<tr>
<td>Donor culture</td>
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<tr>
<td>Religious convictions</td>
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Barriers

5.2.2.1 Smallness and Isolation

Smallness and isolation are terms often evoked to describe the perceived inherent vulnerability of small island states. While several Pacific Island scholars have offered strong rebuttals to the notion that smallness and isolation necessarily contribute to any greater level of vulnerability to climate change (e.g. Barnett and Campbell, 2010, pp. 155-159; Campbell, 2009; Hau’ofa, 1993), it is apparent that smallness and isolation act as barriers to some types of adaptation to climate change in Funafuti.

The small physical size of Funafuti, combined with the problem of overcrowding has left very little space for adaptive manoeuvring, especially by changing locations to reduce exposure. While planting gardens in Funafuti might help alleviate the financial stress of the high cost of food, and installing additional water storage tanks next to homes would reduce stress during times of water shortage, there is very limited unoccupied space in Funafuti on which to pursue these adaptive options. In many places in the world where there is threat of coastal erosion, villages and gardens can be relocated in response; however in Funafuti, there is simply not enough land to allow for this type of relocation.

The isolation of Funafuti from other countries and from Tuvalu’s outer islands is also a barrier to the adaptive options of sharing and relying on the market. Sharing among
family members living in Funafuti and in outer islands is a common practice, although it is unreliable due to weak transportation links to the outer islands. Isolation from external markets is a barrier to market-based strategies of adaptation because distance significantly increases the cost of importing and exporting goods.

5.2.2.2 High Cost of Living and Few Jobs, Low Wages

The high cost of living in Funafuti, combined with few job opportunities and low wages for the few jobs that are available is another significant barrier to adaptation in Funafuti. As described earlier, relying on the market has emerged as a common adaptive strategy as a result of the shift toward commercialization and a cash economy. In theory, the ability to purchase goods such as water, water tanks, and food is an effective means of coping with some of the exposure-sensitivities that people in Funafuti face, but in reality, the ability of people in Funafuti to adapt to stressful conditions by way of purchases is greatly constrained by the economic conditions of Funafuti. For example, the cost of purchasing a water tank in Funafuti is AUD $1700.00. As one respondent described, “We can’t buy our own tanks, we can’t afford it... We would really love to buy some, but we just can’t afford it” (respondent from Vaiaku, age 30, September 7, 2012).

5.2.2.3 Overcrowding

Overcrowding at the island scale exacerbates the barriers caused by the smallness of Funafuti, and constrains many adaptive options. At the household level, overcrowding acts as a barrier to adaptation because many of the adaptive strategies taken by individual households are simply not enough to moderate the exposure-sensitivities because there are too many people in the household. For example, though there are a wide range of reactive, short-term behaviour changes that individuals and households can take during
times of water shortage, these are often still not enough to eliminate water stress, because the demand for water is so high within overcrowded households. When asked whether the water conservation tactics employed by one respondent living in a household of 12 people were effective in combating water shortage, she replied, “It helped but not really because there was a lot of people in our house” (respondent from Teone, age 26, August 13, 2012). In addition, many households are financially stressed, not only because of the economic conditions of Funafuti, but also because they are obligated to provide for a large household.

5.2.2.4 Donor culture

While international aid organizations have made many positive contributions to Tuvalu’s capacity to adapt to a variety of hardships, their extensive involvement has created, what is referred to locally as a donor culture. Donor culture refers to the tendency of many people in Tuvalu to rely on government and donor intervention to address many of the hardships they face. This phenomenon is not unique to Tuvalu. As Fijian scholar Joeli Veitayaki (2009) states:

Modernization in the Pacific Islands has resulted in a dependency attitude, which is the biggest threat to Pacific Island communities today. People are no longer in control of their lives as they are always waiting for the rest of the world to come to their rescue.

Donor culture has become a barrier to individual and local adaptation initiatives in Funafuti.

Perhaps the most vivid example of the way in which donor culture acts as a barrier to adaptation in Funafuti emerges upon an examination of the capacity building efforts in the water sector. As mentioned previously, the water sector in Funafuti has been the recipient of a great deal of international aid attention over the past several years. Efforts to build capacity in this sector have included the distribution of water tanks to households,
water catchment system repair and maintenance, awareness-raising campaigns about good practice in water management, and the distribution of water consumption reduction technology like composting toilets. While these initiatives have made strides in building capacity in the water sector, they have also had the effect of nearly eliminating the motivation for individuals and households to take adaptive action. Although water security is considered a significant issue by the Funafuti community, few individuals or households act to maintain or enhance their water storage capacity. Reasons for this include that many people in Funafuti rent rather than own their properties, most households have limited economic resources, and many people rely on government and aid intervention to meet these needs. When asked what would help the Funafuti community cope with water shortage in Funafuti, respondents most commonly responded that more water storage was what was needed most, and that it was up to the government to provide such projects. An example of this type of response is:

  The government only provides the tanks, not water gutters, so I suggest that if they can provide the water tanks, why not provide water gutters, pay for the labour and cost, and find people to come and fix the gutters instead of just putting the tank over there without water gutters. Because most of the people can’t financially pay for the water gutters and everything so it is better for the government to do that (respondent from Vaiaku, age 33, October 8, 2012).

  Donor culture extends beyond the water sector in Funafuti and is especially apparent in relation to risks associated with climate change. The Funafuti community perceives its role in adaptation to climate change, less as an active agent in the adaptation process, but more as a passive recipient of capacity building projects. Furthermore, the community perceives the government’s role as that of a fundraiser and project proposal writer to secure funding for adaptation projects on behalf of the community. For example,
when asked about the main challenges facing Funafuti, looking to the future, one respondent replied:

It all depends on the people working in the Environment Department, they are the ones who are responsible for proposing projects that can provide [for us]. [For example], make a proposal for a project like a seawall, to protect [us from] erosion or things like that (respondent from Fakaifou, age 60, August 10, 2012).

5.2.2.5 Religious convictions

Tuvaluans have a very strong Christian faith. Approximately 93% of the population belongs to the main Christian Church, the EKT (T. Lusama, personal communication, October 4, 2012). While belief in God is a source of emotional strength for many Tuvaluans, in some ways it represents a barrier to taking action on conditions affecting livelihoods, particularly those related to climate change. Many people in Funafuti believe that everything that happens in their life is due to the will of God. When discussing elements of hardship in their lives many respondents say things such as, “...because it is God’s creation, it doesn’t really worry me” (respondent from Lofeagai, age 56, August 8, 2012). Because of this view, many people in Funafuti do not feel compelled to take adaptive action. They say things such as, “If we think about it, it is not our work, it is God’s creation, so there is nothing else we can do” (respondent from Alapi, age 71, August 14, 2012).

Adaptations to conditions related to climate change are particularly sensitive to the barriers of religious convictions. For example, many Tuvaluans resist the notion of sea level rise because of the story in the Bible in which God tells Noah that never again would a flood cover the Earth. Although the EKT has made efforts to teach its members that there is a difference between God’s covenant to Noah and anthropogenic climate change, faith in God remains paramount in the minds of many people. For example, when discussing the issue of sea level rise, one respondent said, “Most of the Tuvaluans, they put their faith in God,
that Tuvalu won’t sink. The scientists say that it will but most of the Tuvaluans say no because they put their faith in God” (respondent from Vaiaku, age 21, July 26, 2012). Other respondents implied that adaptation to sea level rise climate change is futile because:

That’s God’s creation so... if God decides the water will come up to here, it will come up to here. How many thousands would I spend to build a higher house, but if God decided, it will flood all the way up to there then it will flood all the way up to there (respondent from Tekavatoetoe, age 47, August 15, 2012).

Opportunities

5.2.2.6 Radio Communication

Tuvalu’s only form of national media is Radio Tuvalu operated by the Tuvalu Media Corporation (TMC) on Funafuti. Radio communication plays an integral role in adaptation to ciguatera fish poisonings in Funafuti. During the outbreak of ciguatera in August 2012, Radio Tuvalu listed the contaminated species of fish several times each day, and most respondents indicated that they avoided the species of fish listed by the radio. Evidently, radio communication is effective means of knowledge dissemination among the Funafuti community. Therefore, radio communication represents an opportunity for the dissemination of knowledge regarding adaptation actions in Funafuti.

5.2.2.7 Social capital

Social capital refers to “the norms and networks that enable people to act collectively” (Woolcock & Narayan, 2000). It has been described as “a necessary ‘glue’ for adaptive capacity” (Adger, 2003). Social capital abounds in the Funafuti community. Tuvaluans have extensive familial ties, enduring island community ties, and a strong sense of kinship through their Christian faith. The boundaries of social networks extend beyond the Funafuti community to outer island relatives and communities as well as relatives
living overseas. Primary examples of social capital that have relevance to adaptation in the
context of this research are community fundraising activities, sharing of assets (e.g. local
food and water), and community service. Collective action lies at the heart of Tuvaluan
culture, and as such, social capital represents a significant opportunity for adaptation in Funafuti.

5.2.2.8 Traditional knowledge and activities

Resilience in light of harsh environmental conditions has historically been a key
characteristic of Tuvaluan culture, and was founded upon traditional knowledge of the
local environment, and adaptive measures developed over generations (Resture, 2009).
Traditional adaptive practices employed in Tuvalu are centred on food security (e.g.
storage and preservation of foods), resource management (e.g. fishing gear restrictions,
specific harvesting times, and size restrictions), settlement security (e.g. elevated sites and
resilient structures), and cooperation (e.g. sharing of resources) (Campbell, 2009; Resture,
2009). Unfortunately, many of these traditional adaptive practices are no longer employed
in Funafuti, as a result of the modernizing way of life.

That the use of traditional adaptive practices has declined in recent decades does
not preclude this knowledge and these activities from providing important opportunities
for adaptation in the future. Certainly, the present community conditions in Funafuti are
different from the conditions in which many of the traditional adaptive practices were
developed. Present conditions (i.e. low availability of local resources) may represent
barriers to the implementation of some of these practices; however, with some
adjustments to accommodate the present community context, these practices are likely to
enhance adaptive capacity as they did in the past. Encouraging traditional food
preservation practices, and the building of local, resilient structures, as well as reintroducing traditional fisheries management measures represent possible strategies that would likely enhance the adaptive capacity of the Funafuti community.

5.3 Current Vulnerability to Climatic Conditions

The broad aim of this research is to assess the vulnerability of people living in Funafuti, Tuvalu to risks associated with climate change in the context of multiple stressors. To achieve this aim, the research documents the conditions that currently influence the lives and livelihoods of people living in Funafuti, both climate-related and otherwise. In order to characterize the nature of vulnerability to risks specifically related to climate change, it is critical to tease out the exposure-sensitivities and adaptive strategies that are related to climate change, from those that are less so. Table 5.4 lists the components of lives and livelihoods that are sensitive to climate conditions.
Table 5.4: Components of Lives and Livelihoods in Funafuti Sensitive to Climatic Conditions

<table>
<thead>
<tr>
<th>Component of Lives and Livelihoods</th>
<th>Climate attributes</th>
<th>Implications of climatic attributes for vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water security</td>
<td>• Extended dry spells</td>
<td>Extended dry spells cause severe shortages of water for human consumption.</td>
</tr>
<tr>
<td>Loss of land and flooding</td>
<td>• Extreme sea levels</td>
<td>Extreme sea levels cause localized flooding. Impacts are particularly dangerous when high tide events and strong winds occur simultaneously. Coastal erosion driven in part by sea-level rise and accelerated by wind-generated waves, is causing the loss of land along some shorelines, particularly in the outer islets.</td>
</tr>
</tbody>
</table>
| Local food security               | • Extended dry spells  
• Extreme sea levels  
• Strong winds  
• Sea-surface temperature/ocean acidification | Drought reduces the availability of local food from the land and gardens. Salt water intrusion, driven by extreme sea levels, damages *pulaka* pits and crops. Changes in the marine environment such as sea surface temperature and ocean acidification may play a role in the reduced availability of fish, and likely play a role in the incidence of ciguatera fish poisoning outbreaks. Strong winds can damage crops and prevent inter-island transportation which provides vital links for local food exchange between the outer islands and Funafuti. |

In Funafuti, a combination of changing climatic conditions and changes in livelihoods has altered, and tended to increase, the exposure-sensitivity of the community to climatic risks. This analysis focuses on current vulnerabilities specifically related, directly or indirectly, to changing climate attributes, although interaction of the various processes (both climatic and non-climatic) that shape exposure-sensitivity and adaptive strategies will be discussed. Figure 5.5 illustrates the complex interaction of multiple climatic and non-climatic factors that affect exposure-sensitivity and adaptive strategies.
Figure 5.3: Factors influencing the vulnerability of the Funafuti community to climate-related risks
as they are discussed in the following sections. The following sections draw on all sources of information including unprompted and prompted responses during community interviews, key informant interviews, secondary sources of information, and participant observation.

5.3.1 Water Security

The Funafuti community’s water system is extremely vulnerable to dry spells. Drivers of the water system’s exposure-sensitivity to dry spells include: the nature of the water harvesting system, climate conditions, and overcrowding.

Funafuti’s current system of water harvesting (described in Section 3.2.3.3, Water Harvesting) is extremely sensitive to dry spells because it is completely dependent on rainfall. The system functions well under normal conditions because Funafuti receives plentiful rainfall during most of the year; however, dry spells do occur, and these stress the water system.

Dry spells in Funafuti are caused by climatic conditions including seasonal patterns of wet and dry weather, as well as the ENSO phenomenon. The dry season in Funafuti extends from April until October. During these months, it is not uncommon for Funafuti to experience a period of little to no rainfall lasting a few days or weeks. Dry spells that span months also occur in Funafuti. These dry spells correlate with La Nina events. Short dry spells are sufficient to cause domestic water shortages in some households in Funafuti, while long dry spells (such as that experienced in 2011) can cause severe domestic water shortages island-wide.

During dry spells, the process of water harvesting in Funafuti adapts in a variety of ways. During dry spells that last for a couple of days or weeks, individuals in Funafuti
employ several reactive, short-term behaviour changes such as conserving water and rationing water to adapt to the shortage of fresh water. Sharing of water between households and among members of island communities is also a common response, as is purchasing water from the government’s large cistern beneath the Government Building, although there are some barriers associated with these adaptive options.

As described earlier, the adaptive strategy of sharing is still widely employed in Funafuti, although some respondents described that declining social cohesion in Funafuti is causing some people to expect something in return for sharing. Similarly, although purchasing water and extra water tanks are possible adaptive options, most families on the island struggle financially so this option is limited. Finally, as described in Section, 5.2.2.4, Donor Culture, one of the major barriers to adaptation of the water harvesting system is that people in the Funafuti community tend to rely on government and aid intervention for capacity-building and maintenance of the water harvesting system.

During extreme dry spells (such as that which occurred in 2011) aid and government intervention play key roles in the adaptation of the water harvesting system. In 2011, the government took control of as much of the system as they could and rationed households. Once the Government of Tuvalu declared a state of emergency, several aid agencies donated freshwater and desalination units. Clearly, the extreme dry spell of 2011 exceeded the Funafuti community’s coping ability.

The water system in Funafuti can cope with (or adapt to) normal climatic conditions and moderate deviations from the norm, but extreme dry spells appear to lie outside the coping range of the community. The duration of dry spells that households in Funafuti can cope with varies. This variation appears to mostly be dependent on overcrowding.
Similarly, the ability of the Funafuti community to cope with dry spells is bound by two overarching factors. Overcrowding and the duration of the dry spell appear to be the factors that dictate how severely community members are affected by water shortages. As described in Section 5.1.1.4, *Overcrowding*, overcrowding at the household scale (i.e. the number of people per household) appeared to influence how much respondents indicated that they suffered during the dry spell in 2011. Overcrowding at the island scale (i.e. the number of people living in Funafuti) is also considered an important factor influencing vulnerability to water shortage in Funafuti because it increases the community’s sensitivity, and limits the community’s adaptive capacity to water shortage.

The vulnerability of Funafuti’s water system to extended dry spells is best understood as a result of the interaction among multiple stressors. In this case, exposure-sensitivity is a result of the interaction among climate conditions and the social, cultural, and economic conditions that cause overcrowding in Funafuti. The adaptive capacity of households to water shortage is constrained by the blurred boundaries of responsibility for water harvesting systems that have resulted from donor intervention and changes in land tenure, as well as the economic hardship experienced by most households.

5.3.2 Loss of land and flooding

Loss of land and periodic flooding, resulting from coastal erosion and extreme sea levels, are risks faced along some shorelines and in some low-lying areas in Funafuti. Coastal erosion and extreme sea levels are influenced by a variety of climate-related conditions including sea-level rise, strong winds, storm surges, and ENSO.

There are few measurements of coastal erosion in Funafuti. Respondents describe that they have witnessed the main islet becoming more narrow over time, especially in
certain places like Lofeganai. Respondents tended to indicate that coastal erosion on the outer islets was more dramatic than what they have noticed on the main islet, Fongafale. Loss of land on the outer islets is particularly problematic for the indigenous Funafuti people who own the land on the islets. When discussing the issue of coastal erosion in the outer islets, it was also common for respondents to describe that erosion of islet shorelines was often accompanied by accretion on another section of the shoreline. For example, a Funafuti elder described:

> From what we know about coastal erosion... it will be eaten up from that piece of land but it will come up on the other side of the land. So it rotates. If you look at Fualifeke [an islet of Funafuti Atoll] now, Fualifeke before is like this [respondent uses gestures to describe the shape of the islet], but now it is like this [respondent gestures a slightly different shape]. Fualifeke is not standing like this but it is standing like that. And it is this side of it is facing this way ... which means the land of the people from this side is disappearing but other people that own the land from the other side will get more land (respondent from Alapi, age 71, August 14, 2012).

This is the same process described by Webb & Kench (2010), who used evidence from historical aerial photography and satellite images taken over the period of several decades to analyze physical changes in 27 atoll islands in the central Pacific. In fact, Webb & Kench (2010) included in their publication an image of the exact process the respondent described in Fualifeke Islet (see Figure 5.5). Overall, results of the Webb & Kench (2010) study show that 86% of islands remained stable or increased in areas, while only 14% exhibited a net reduction in island area over the timeframe of analysis. Despite small changes in the net island area, islands showed variable morphological changes, with 65% of islands undergoing net lagoonward migration. Respondents noted that even though erosion on the islets was often accompanied by accretion in other areas, the net change was still problematic because the accretion does not completely compensate for the erosion,
and the erosion causes the loss of coconut trees that the accretion of sand does not compensate for.

![Diagram of shoreline changes](image)

**Figure 5.4:** Fualifeke (above, right), an islet in the northern part of Funafuti Atoll, showing erosion and accretion on different parts of the shoreline between 1984 and 2003. The same process described by a Funafuti elder (adapted from Webb & Kench, 2010)

Respondents share varied notions about changes in sea level over time. Some believe that there had been no change, while others believe that extreme sea level events occur more frequently than in the past. Most believe that high tide events occur with the same frequency, but that the most recent events are more severe than those in the past. Many assert that it is the combination of high tide events and strong winds that cause the most severe flooding events; a high tide event, without wind was a normal high tide, but a high tide event plus wind was exceptionally severe. For example, an indigenous Funafuti elder living in Alapi said:

> From what we know, the king tide is in February. That's when it happens, ever since before. But it is different nowadays. Only if there is wind. If there is a touch of wind, then all of their stuff will be destroyed, from the look of it (respondent from Alapi, age 71, August 14, 2012).

Wind generated waves and storm surge also have implications for coastal erosion in Funafuti. Strong westerly winds occur at intervals during the wet, bad weather period
from November until March, although recently, strong winds have been occurring outside of this season. As described earlier, tropical cyclones occasionally begin to develop close to Tuvalu, and even though it is rare for Tuvalu to suffer a direct hit from a hurricane, the swell generated by distant storms can cause significant impacts in Funafuti (Walsh et al., 2012). For example, the occurrence of three tropical cyclones in 1997 near Tuvalu (Gavin and Hina in March, and Keli in June), led to the complete loss of vegetation on one Funafuti’s outer islets called Tepuka sa Vilivili (Walsh et al., 2012). The Tuvalu MET office has documented no change in the frequency of cyclones that have developed near Tuvalu over the past several years, but has noted that the cyclones are more intense than in the past (T. Katea, personal communication, September 26, 2012).

Measurements of sea level rise in Funafuti show a positive sea level trend. Sea level has been measured in Funafuti by two separate gauges since 1977. The record from the first gauge installed offers a 23-year sea level record for Funafuti, and the monthly sea level data for this record shows a trend of +0.9mm/yr (Australian Bureau of Meteorology, 2010). A relatively modern SEAFRAME gauge, with more precision than that installed in 1977, was installed in Funafuti in 1993. The sea level trend from this gauge to date is +4.0mm/year although the magnitude of the trend continues to vary widely from month to month because the sea level record is quite short (Australian Bureau of Meteorology, 2010). When considered together, as shown in Figure 5.3, it is clear that despite the large inter-annual variations, the sea level trends observed in Funafuti are consistent with the regional patterns and rates of sea level rise in the Pacific, in the order of +2mm/year.
Figure 5.5: Mean sea level in Funafuti from 1977-2008 (adapted from Webb & Kench, 2010)

Increases in mean sea level are only one component of extreme sea levels. Extreme sea levels are the result of several coinciding processes, including astronomical tides and tropical cyclones, which generate elevated coastal sea levels through storm surge and high waves (see Figure 5.4) (Walsh et al., 2012). As respondents indicated, it is the combination of high tide events, and strong winds, which lead to the extreme sea level and wave run-up to which low-lying and coastal areas in Funafuti are sensitive.
Figure 5.6: Diagram illustrating the contributions to extreme sea levels. The combined factors of high tides and wind-generated waves are particular pertinent to the Funafuti community (adapted from Walsh et al., 2012).

Sensitivity to these conditions (at least on Fongafale Islet) is driven largely by the expanding pattern of settlement in Funafuti. The urbanization of Funafuti, which has driven extensive rural to urban migration since Tuvalu’s independence has caused the expansion of settlement in Funafuti from the original villages of Senala and Alapi into the marginal lands in the extreme ends of Fongafale Islet, the low-lying areas of Fakaifou, and surrounding the burrow pits. Members of the Funafuti community living in the marginal coastal and low-lying areas are exposed and sensitive to loss of land resulting from erosion, and periodic flooding resulting from extreme sea levels.

For example, one respondent who had lived in Lofeagai for 10 years described that he and his grandson had built a seawall to protect their house from the sea during high tides. He said:

When we came to this land, when we settled here the sea would come all the way up to the umu (local, open-air house) ... It would be really hard for us to build things. Our farm before ... we had pigs here, so when it was high tide it would destroy our farm. When it was really high tide some of our pigs were floating in the sea. We would have to go and get them (respondent from Lofeagai, age 70, August 9, 2012).
Another respondent from Tekavatoetoe described how her family’s house was affected during the spring tides:

...Our house is near to the sea and the lagoon. It is near to both. So to me [spring tide] is a big problem because we can see the sea and the lagoon. [During one spring tide] all of the tanks, they were moved by the tide, and also the small stones were pushed up to the house by the tide. So there’s a big problem. So everyday, we had to sweep the surroundings and take the stones back to the sea shore (respondent from Tekavatoetoe, age 19, August 22, 2012).

In the Funafuti community, little adaptive action has taken place regarding vulnerability to loss of land and flooding. There are some instances in which individuals and households have modified their surroundings (e.g. by constructing sea walls, or elevating gardens) or changed location (e.g. by shifting their house or relocating their crops) to reduce their exposure, but these cases are exceptional. A majority of community members cope with these exposure-sensitivities by bearing the consequences.

The adaptive capacity of the Funafuti community to deal with this particular component of vulnerability is limited for a number of reasons. First, the magnitude of the problem is such that the adaptive possibilities are not many, especially at the individual and household scale. As one respondent stated, “It is the sea’s work so us human beings, we can’t do anything” (respondent from Senala, age 55, September 4, 2012). Second, relocation is arguably the most effective means of coping with vulnerabilities associated with settlements built upon marginal lands, but the smallness of Funafuti bars most strategies involving a change of location. Third, donor culture is a significant barrier to adaptation to loss of land and flooding, because these problems have been at the centre of the attention that Tuvalu has received recently in light of climate change. Tuvaluans are aware that loss of land an inundation by the sea are anticipated consequences of a changing climate and they expect that the international community will assist Tuvalu in coping with
these challenges. Fourth, religious convictions regarding climate change are rooted in the covenant that God made to Noah, that no flood would ever again cover the Earth. As a result, many people in the community do not believe they should act in response to loss of land and flooding, but rather put their faith in God. For example, one respondent said, “…if we think about it, it is not our work, it is God’s creation, so there is nothing else we can do” (respondent from Alapi, age 71, August 14, 2012). Finally, a lack of resources, both financial and raw material represent a barrier to adaptation to this component of vulnerability at the individual and household level. Without these resources, the ability for individuals and households to modify their surroundings to reduce exposure (e.g. by constructing a sea wall, or raising their homes on stilts) is limited. While lack of financial resources as a result of the high cost of living, few jobs, and low wages in Funafuti, is problematic for most of the Funafuti community, those living in the marginal areas are even more likely to lack financial adaptive capacity. The villages of Lofeagai and Tekavatoetoe, as well as the land surrounding burrow pits tends to be occupied by people who have migrated from outer islands seeking job opportunities (Tuvalu Red Cross, 2012). Since they do not own the land on which they reside, they are not entitled to take resources from the land.

An examination of the current vulnerability to loss of land and flooding in Funafuti reveals an interesting pattern of spatial distribution: vulnerable households are those occupying marginal lands. Though this finding may not be surprising it reveals that the rapid urbanization of Funafuti, which causes outer island families to inhabit land that was historically unoccupied, is the underlying factor that creates this exposure-sensitivity. Furthermore, the adaptive capacity of households to this exposure-sensitivity is
constrained by a variety of factors outlined above. It appears that households occupying these marginal lands are not only the most exposed and sensitive to loss of land and flooding, but also the least able to adapt.

5.3.3 Food Security

Food security in Funafuti is threatened by a variety of conditions, some of which are climate-related. Climatic conditions that affect the food system include: dry spells, sea-level rise, strong winds, increasing sea-surface temperatures and ocean acidification.

In Funafuti, dry spells, strong winds, and extreme sea levels, have implications for the community's ability to produce and harvest local food. Dry spells cause crops to wither, food-bearing trees to die, and strong winds damage crops and food-bearing trees. Extreme sea levels also damage gardens and crops by way of salt water intrusion.

Webb (2007) conducted an assessment of salinity of groundwater in pulaka pits in Tuvalu. This study found an overall trend of high salinity in pulaka pits on Fongafale Islet, well above the optimum range for successful pulaka cultivation. It is worth noting that only pulaka pits in Funafuti, and two other pits in Nukulaelae and Nuitao recorded salinity ranges too high for pulaka cultivation. The particularly saline pit in Nukulaelae is known locally to have a history of salt water contamination, and in Nuitao, anecdotal evidence suggests that engineering may have contributed to the salt water contamination. Otherwise, the study found that all other sample locations on Nukulaelae, Nuitao, and all other islands had average groundwater salinity that was within the range to allow successful pulaka cultivation. Webb (2007) concludes that it is not known to what extent, if any, sea level rise may contribute to the significantly higher salinity measurements in Funafuti; however, he notes that:
...it would seem reasonable to expect that an overall failure of an atoll’s groundwater lens in response to recent sea-level change would manifest as a more uniform sub-regional or regional phenomena. It is difficult in view of the results gained here to therefore link Fongafale’s groundwater salinity issue to sea-level change alone. Rather, it is most likely that the groundwater salinity issue on Fongafale is not wholly related to any one particular factor but rather a range of possible causes, which act in synergy. These include natural hydrological features of the island; past engineering and land forming changes; and more recently ongoing population and development pressures.

Food security in Funafuti is also exposed and sensitive to strong winds, which have implications for transport links that are vital to the delivery of imported food from Fiji, and local food from the outer islands. Any strong wind warning issued by the MET office automatically causes ships to remain docked, which disrupts the delivery of imported foods and local foods.

Finally, while increasing sea-surface temperatures and ocean acidification have not been confirmed as conditions directly affecting food security in Funafuti, it is known that these conditions play a role in the decline of coral reef health and fish populations (Hoegh-Guldberg & Bruno, 2010), as well as the increased incidence of ciguatera fish poisoning (Hales et al., 1999). The prevalence of ciguatera increases dramatically where average sea surface temperatures are at least 28° to 29°C. Elevated sea surface temperatures associated with climate change are believed to already be exacerbating the extent and range of ciguatera (Skinner et al., 2011). Leaders in the Department of Fisheries noted positive trends in the number of ciguatera cases, number of species affected, and the extent of affected areas (Anonymous, personal communication, October 15, 2012). Unfortunately, in Tuvalu and across the Pacific Islands region, ciguatera poisoning is under-diagnosed and under-reported, so data to support these trends is sparse and unreliable (Goater et al., 2011; Skinner et al., 2011).
Non-climatic conditions that threaten food security include: overcrowding, the nature of land tenure in Funafuti, as well as changing dietary preferences and cultural practices. Overcrowding in Funafuti limits the amount of space on which the community is able to produce and harvest local food. The nature of land tenure also contributes to the vulnerability of the food system in Funafuti because a majority of the population is unable to own land on which to produce and harvest local foods. Finally, as a result of changing dietary preferences and cultural practices, the production and harvesting of local food, especially traditional food like pulaka, is no longer a central feature of daily life in Funafuti.

For example, there are three main pulaka pits in Funafuti, two of which have seen approximately 80% abandonment, while the third has seen approximately 50% abandonment. Reasons for this abandonment include salt-water intrusion and drought; however, disinterest on behalf of the younger generation, migration away from Funafuti, and changing food preferences are also important drivers of this abandonment. As a leader in the Department of Agriculture described, “There are a lot of abandoned pits, but it doesn’t mean it has come to a level where you can’t grow [pulaka] because of salinity” (Anonymous, personal communication, October 17, 2012).

A suite of non-climatic conditions also contribute to the vulnerability of food security in Funafuti as it relates to the decline of fisheries and ciguatera poisoning. Fishermen attribute the decline in the fisheries in the Funafuti lagoon to overfishing as a result of overpopulation. Leaders in the Department of Fisheries see the decline as a consequence of the complex interaction of multiple factors, of which increased fishing activity is just one. According to one Department of Fisheries member, as well as personal observation, the coral reef in the lagoon is bleached and dead, the water used to be clear.
but it is now murky, and there is a lot of algae (Anonymous, personal communication, October 15, 2012). Causes of the degradation are not well understood but are likely to include poor waste management, increased ultraviolet exposures, warming ocean temperatures, and increasing acidity (Anonymous, personal communication, October 15, 2012; Hoegh-Guldberg & Bruno, 2010). Also, pressure on the reef is driven by changes in traditional resource management practices and modern fishing methods (Anonymous, personal communication, October 15, 2012; Veitayaki et al., 2007). For example, people in Funafuti used to target certain sizes of fish (similar fisheries resource management strategies are still practiced in the outer islands), but now they will take whatever they can get, and while people used to fish with only nets, they now use torches, fish finders, engines, and GPS technologies (Anonymous, personal communication, October 15, 2012). A number of non-climatic factors have been associated with incidence of ciguatera. Algal growth, uncontrolled by herbivorous fish, and coral reef damage, provide the conditions for *Gambierdiscus* growth that might increase the risk of ciguatera. For example, military activities in the Funafuti lagoon during WWII have been linked with an outbreak (Ruff, 1989).

The food system in Funafuti adapts in a variety of ways to the climatic threats to which it is exposed and sensitive. Over the past couple of decades, Funafuti’s food system has shifted away from local, subsistence production and harvesting of food to a commercial system dependent on imports and a cash economy. While it is primarily non-climatic conditions that have caused this shift, the commercialization of the food system is now an important component of the food system’s capacity to adapt during periods of climatic stress. In the event of crop damage from droughts or salt-water intrusion, community
members can simply turn to the shops to meet their food needs. Of course, economic hardship is a significant barrier for many households in Funafuti to rely on market-based adaptive strategies, and as such, sharing of local foods from relatives in the outer islands is also an important adaptive strategy. Networks of food sharing by way of transportation from the outer islands are occasionally hindered by strong wind events, but currently, this climatic condition is not a significant barrier to the adaptive strategy of sharing local food among relatives on outer islands.

Bearing the consequences of climatic conditions that stress the local food system by abandoning crops, letting crops die and replanting them at a later time is another common adaptive strategy employed in Funafuti. The prevalence of this adaptive option is linked to a broader shift toward a market-based food system.

Current vulnerability of the food system in Funafuti to climate change is driven by a variety of stressors, only some of which are climate related. Overcrowding, the nature of land tenure in Funafuti, changing dietary preferences and cultural practices, as well as the shift toward a market-based food system comprise the context in which this particular component of vulnerability is experienced.
CHAPTER SIX: Future Vulnerability

This chapter presents results for the third objective of this research, which is to assess community vulnerability in the future by estimating changes in exposure-sensitivities and adaptive capacity. Current exposures are examined in light of future climate change projections to provide insight into the nature of future climate-related exposure-sensitivities. Similarly, adaptive capacity is examined relative to anticipated changes in social and economic conditions, which are expected to influence the nature of future adaptations.

Analysis of current vulnerability to climate change indicates that three components of lives and livelihoods in Funafuti (i.e. water security, loss of land and flooding, and local food security) are vulnerable to climatic conditions. The climatic conditions that influence these components of vulnerability are extended dry spells, extreme sea levels, strong winds, and sea-surface temperature and ocean acidification. Table 6.1 summarizes the implications of future climate change for these attributes of climate.
Table 6.1: The implications of future climate change for community-identified climatic risks

<table>
<thead>
<tr>
<th>Climate attributes</th>
<th>Climate change predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended dry spells</td>
<td>• Fewer rainy days, but an increase in rainfall intensity (Lal, 2002; Trenberth, 2011)</td>
</tr>
<tr>
<td></td>
<td>• Marginal change in annual rainfall (Mimura et al., 2007)</td>
</tr>
<tr>
<td></td>
<td>• Little confidence in whether the amplitude or frequency of ENSO is likely to change (Collins et al., 2010; Walsh et al., 2012)</td>
</tr>
<tr>
<td>Extreme sea levels</td>
<td>• Increase in mean sea level (Walsh et al., 2012)</td>
</tr>
<tr>
<td></td>
<td>• Uncertainty regarding the contributions of storm surges and wind driven waves (Walsh et al., 2012)</td>
</tr>
<tr>
<td>Strong winds</td>
<td>• Possible increase in intensity of storms, but overall decrease in storm frequency (Meehl et al., 2007; Walsh et al., 2012)</td>
</tr>
<tr>
<td></td>
<td>• No consistent predictions regarding cyclone genesis or tracks</td>
</tr>
<tr>
<td>Sea-surface temperature and ocean acidification</td>
<td>• Gradual increases in sea-surface temperature and ocean acidification (Collins, 2010; Feely et al., 2009; Lal et al. 2002)</td>
</tr>
</tbody>
</table>

Extended dry spells in Funafuti have implications for water security and local food security. While Mimura and colleagues (2007) indicate there will be only a marginal change in annual rainfall, Lal (2002) predicts fewer, but more intense precipitation events. Rainfall in less frequent but more intense events poses a problem in Funafuti because water resources are limited by storage capacity. Intense rainfall events also pose a problem for gardens because they can easily wash away thin layer of man-made topsoil required to maintain a garden in Funafuti. In addition, even a slight reduction in average rainfall would reduce the size of the freshwater lens in Funafuti. While the lens in Funafuti is fairly brackish even under the best conditions, it remains an important back-up source of nearly fresh water during dry spells. A reduction in the size of the fragile freshwater lens would also be detrimental to pulaka production, which is already at risk. Knowledge
regarding whether extended dry spells will increase or decrease in Funafuti in the future is limited by the current inability to predict future changes in ENSO. Collins et al. (2010) describe that while factors that control the characteristics of ENSO are likely to be affected by warming, the changes in the amplifying and dampening processes could partly cancel each other out; therefore, it is not clear at this stage which way ENSO variability will tip. It could intensify, weaken, or undergo little change depending on the balance of changes in the underlying processes. Since ENSO is the main driver of interannual variability in rainfall in Tuvalu, our knowledge of exposure to extended dry spells in Funafuti is limited by this gap. Despite current inability to predict future changes in ENSO it is still reasonable to conclude that water resources in Funafuti will be under greater threat in the future due to the global trend toward fewer rainy days, but increased rainfall intensity (Trenberth, 2011).

Future changes in sea level extremes will be caused by a combination of changes in mean sea level, regional sea level trends, tropical cyclone incidence, and wave climate (Figure 6.1) (Walsh et al., 2012). While there is wide agreement on predicted increases in mean sea level, there is still great uncertainty surrounding how tropical cyclone and ENSO behaviour will change in the future (see Table 6.1). Due to these large uncertainties, no studies to date have attempted to project future changes to sea level extremes in the South Pacific (Walsh et al., 2012). The difficulty predicting trends in future storminess is especially problematic for Funafuti because respondents have stated that it is the combination of high tides and strong winds to which they are particularly vulnerable. Nevertheless, mean sea level trends will still undoubtedly increase the extreme sea levels experienced by the Funafuti community in the future. Sensitivities to extreme sea level rise
in some areas of Funafuti are already acute, and more extreme sea levels would serve to exacerbate impacts in these areas and potentially expand affected regions.

A majority of simulations suggest that climate change will cause a decrease in the frequency of tropical cyclones in the future. Some simulations have indicated increases in the intensities of the strongest storms (although others suggest no change or decreases); however, combined with projected decreases in number, this would suggest a decrease in the number of intense tropical cyclones in the South Pacific. Unfortunately, there appears to be no agreement on predictions in cyclone genesis locations and tracks. Some models predict no change in tropical cyclone formation regions, others predict cyclones forming north and others further south. Although direct strikes of cyclones on Funafuti are uncommon, the societal impacts are immense. Funafuti will face a greater risk for more frequent direct strikes of cyclones if cyclones form further north in the South Pacific in a changing climate. This was the case in Hurricane Bebe in 1972. Nevertheless, cyclones need not be in close proximity to produce an impact. While there is still uncertainty with respect to cyclone genesis and tracks, that there will likely be fewer cyclones in the future is advantageous for Funafuti, especially with regard to reduced coastal erosion and extreme sea levels through waves.

Sea surface temperature and ocean acidification are associated with changes in the marine environment surrounding Funafuti and, therefore, have implications for local food security. The average temperature and acidification of the upper layers of the ocean have risen in close correlation with increasing concentrations of CO₂ in the atmosphere. This trend is projected to continue in the future (Feely et al., 2009; Hoegh-Guldberg & Bruno, 2010). Among the most profound implications of these changes are their impacts on
habitat-forming species such as corals. Coral reefs form habitats for thousands of other species. As a result of increasing temperatures, coral bleaching and mortality will reduce the richness and density of coral reef fishes and other organisms. These marine ecosystems are a critical source of food for the Funafuti community and disruptions to this ecosystem would be detrimental to food security. The coral reef ecosystems surrounding Funafuti are already stressed. While it is nearly impossible to pinpoint the exact drivers of the decline in this ecosystem’s health, the decline is likely due to a combination of coral bleaching, reduced calcification, increasing inputs of sediments and nutrients, pollution, overfishing, increased UV exposure, and warming surface layers driving changes in community structure and food web dynamics (Anonymous, personal communication, October 15, 2012; Hoegh-Guldberg & Bruno, 2010).

Furthermore, analysis of current vulnerability to climate change indicates that most of the social, economic, and cultural conditions (e.g. overcrowding, high cost of living, few jobs, low wages, etc.) that drive exposure-sensitivity will either continue or increase in the future. Since many of these characteristics are similar to those that constrain the community’s adaptive capacity, it is reasonable to predict that Funafuti’s adaptive capacity will continue to be limited in the future. Notwithstanding these constraints to adaptation, there is potential for enhancing adaptive capacity in the future by pursuing the opportunities for adaptation in Funafuti. Perhaps one of the most promising modes of enhancing adaptive capacity in Funafuti is the pursuit of adaptive strategies that utilize the characteristics that have historically made Tuvaluans resilient in the face environmental adversity. These include their deeply ingrained sense of community and traditional knowledge and activities.
Tuvalu will likely continue to receive the attention of international donors in the future, especially in light of the impacts of climate change. These external interventions are most likely to effectively enhance adaptive capacity in Funafuti if they are mindful of the local context, and seek to design adaptation initiatives that are centered on the strong community networks in Funafuti.

At the same time, it is important for leaders in the Funafuti community to promote community-driven adaptation initiatives. Community-driven initiatives have a great deal of potential due to the immense social capital in Funafuti. An example of such an initiative might be the promotion of traditional adaptive activities, such as resource conservation or food storing techniques that have been abandoned in response to the modernization of Funafuti.
CHAPTER SEVEN: Conclusions

This chapter summarizes the main messages of this research and highlights scholarly and practical contributions of this work. The chapter is divided into four sections. The first section outlines the key findings of the research. The next section discusses the scholarly contributions of this research in the context of the broader field of climate change in the Pacific Islands. This is followed by an exploration of the practical contributions of this work to future adaptation planning. The chapter concludes by suggesting possibilities for future research opportunities.

7.1 Summary of Key Findings

The main messages of this research can be summarized as follows:

1. **The conditions affecting lives and livelihoods in Funafuti are: the economic circumstances, the nature of the food system, fresh water insecurity, overcrowding, the nature of Tuvaluan culture and cultural change, extreme sea levels, coastal erosion, strong winds and cyclones, temperature, unpredictable weather, and ciguatera fish poisoning.**

   The results of this study demonstrate that climate change is but one stressor affecting lives and livelihoods in Funafuti. While Funafuti is exposed and sensitive to a variety of climatic conditions, these are not the most pertinent conditions affecting lives in the community at present. When asked in an unprompted manner about the conditions affecting their lives, people in Funafuti tended to respond first by referring to the same suite of interconnected socio-economic and cultural conditions (i.e. overcrowding, the economic circumstances, the food system, and the cultural forces and changes). When respondents referred to climatic conditions that affected their life or livelihood, it was evident that vulnerability to climatic change was woven into the fabric of the underlying cultural, and socio-economic conditions, such that it was essential to understand this
context in order to understand the ways in which climate change is affecting people in Funafuti.

The results of this study reinforce those of other projects that have been conducted in the Pacific Islands examining vulnerability and adaptation to changing conditions in the context of multiple stressors. For example, work in the Solomon Islands has indicated, as this study has, that population growth and the transition to a cash economy are key drivers of stress in Pacific Island communities (Fazey et al., 2011; Reenberg et al., 2008). In addition, work in Kiribati has indicated that culture, especially religion, plays a key role in community vulnerability, which is mirrored in this study (Kuruppu, 2009).

2. **The community of Funafuti is vulnerable to climate change risks associated with water security, loss of land and flooding, and food security.**

An examination of the role of climate with respect to other stressors affecting the community of Funafuti reveals that climate plays a role in water security, loss of and land flooding, and food security. While these three components of lives and livelihoods are impacted by climatic factors, their vulnerability is also closely linked with non-climatic factors. This reinforces the expressed need to consider vulnerability to climate change in the context of multiple stressors (Reenberg et al., 2008; O’Brien et al., 2009. Additionally, this research actually identifies where and how different stressors interact in a Pacific Island community context.

For example, the results of this study indicate that exposure-sensitivity to water shortage in Funafuti is a function of not only extended dry spells, but also of overcrowding at the island and household scale. In addition, exposure-sensitivity to flooding in Funafuti is a function of not only extreme sea-levels, but also of the changing pattern of land use that has caused human settlement to expand into low-lying areas, which is driven by
overcrowding as a result of urbanization. This examination of multiple stressors highlights the connectedness among forces, and across scales, by demonstrating that vulnerability to climate change in Funafuti is as much a function of overcrowding, urbanization, few economic opportunities, changing land use, and cultural norms, as it is a function of dry spells, sea levels, strong winds, and changing marine conditions. Evidently, vulnerability to climate change in Funafuti is the product of a synergy of forces.

3. **The main adaptive strategies employed in Funafuti are: bear the effects, reactive, short-term behaviour change, rely on the market, rely on traditional knowledge and activities, share the burden, rely on aid or government intervention, change locations to reduce exposure, and modify surroundings to reduce exposure.**

   Adaptation in Funafuti occurs through a variety of processes that function to accept, modify, or change exposure-sensitivities, and/or to enhance adaptive capacity. Adaptations to climate-related stressors tend to be reactive to acute changes in conditions. In other words, there is little evidence of proactive adaptation to changes in climatic conditions. In addition, most adaptation to climate-related stressors relies on external support (e.g. aid, imports, and resources from outer islands). For example, food security in Funafuti is likely to be affected by climate change, but traditional food storage and traditional fisheries management practices are no longer employed in Funafuti. Sharing of foods is still an important component of maintaining food security, but this food is shared among relatives from outer islands. Very little local food is produced or shared within the Funafuti food system.

   That adaptations to climate-related stressors tend to be reactive, and event-driven is a feature of adaptation widely observed in the Pacific Islands region (Bridges & McClatchey, 2009; Lata & Nunn, 2012; Reenberg et al., 2008). While understandable, especially in a developing country context, reactive adaptation is likely to be insufficient in
the future as climatic conditions become more extreme and hazardous events occur more frequently. Additionally, other work in the Pacific Islands has indicated that reliance on external support is also characteristic of adaptation in the region. For example, Barnett (2008) and Veitayaki (2009) describe the increasing reliance on foreign aid in the Pacific Islands region, and indicate that aid has had different effects on adaptive capacity in Pacific communities.

Adaptation in Funafuti also occurs across interacting scales that include individuals, households, communities, the national government, and international organizations. For example, water tanks donated by international aid organizations to the Government of Tuvalu and distributed to households play a critical role in adaptation to water shortage; equally important in water shortage adaptation, are the reactive, short-term behaviour changes taken by individuals and households, which depend upon household stores of water in tanks.

While this research focuses primarily on adaptive strategies employed by individuals and households, other work in the Pacific has analyzed the ways in which broader power structures within Pacific Island societies influence adaptation. For example, Kuruppu (2009) found that in Kiribati, religion plays a significant role in adaptation, especially as power structures within the church delimit benefits to the individual, preventing people from acting independently to achieve personal well-being. While it was outside the scope of this research to analyze the broader power structures within which adaptation occurs in Funafuti, this work supports the findings of Kuruppu (2009) and reinforces the possibility of examining the processes of adaptation on different scales.
4. Barriers to adaptation in Funafuti include: smallness and isolation, high cost of living and few jobs, overcrowding, donor culture, and religious convictions. Aids to adaptation in Funafuti include: radio communication, social capital, and traditional knowledge and activities.

The suite of socio-economic and cultural conditions that influence exposure-sensitivities in Funafuti, also act as barriers and aids to adaptation. Understanding the factors that aid or constrain Funafuti’s adaptive strategies provides insight into Funafuti’s potential to adapt to future changes in conditions, and facilitates the design of adaptation interventions that suit the local context and may enhance adaptive capacity in the long term.

With respect to barriers to adaptation, the results of this study support the findings of Barnett (2008) and Veitayaki (2009) who indicate that aid has mixed effects on the capacity of Pacific Islands to adapt to climate change. For example, in a case study of Niue, Barnett (2008) found that aid has improved the availability of finance for adaptation, but has undermined the legitimacy of government actions. The research presented in this thesis also finds that aid influences the adaptation process in different ways in Funafuti. For example, in the water sector, aid has enhanced some elements of adaptive capacity by increasing household water stores, but the predominance of aid and the reliance on it has limited the incentive of people to put their own resources toward the maintenance and improvement of water storage. Of course, individual and household initiatives to adapt to water shortage are also constrained by very limited financial resources.

Other work on adaptive capacity in small islands has indicated that self-efficacy (the belief in one’s own ability to complete tasks and reach goals) plays a key role in adaptation and is linked to increased resilience in communities (Kuruppu & Liverman, 2011; Tompkins, 2005). The finding that donor culture in Funafuti is a barrier to adaption
complements this work. If self-efficacy is a precursor to protective action, the donor culture in Funafuti is a critical barrier to overcome.

With respect to the conditions that facilitate adaptation, the findings of this study reinforce the work of others who have indicated that strong social networks and willingness to act collectively are a key feature of adaptation in Pacific Island communities, and small island communities more broadly (Reenberg et al., 2008; Tompkins, 2005; Veitayaki, 2009). This research suggests that adaptation interventions that are designed based upon the communal nature of the Funafuti community, are likely to enhance adaptive capacity in the long term.

7.2 Scholarly Contributions

Some authors have noted a need for locally oriented, empirical studies of vulnerability to climate change in the Pacific Islands region (Barnett and Campbell, 2010, p. 80; Kelman & West, 2009; Schwarz et al., 2011). This research responds by providing a vulnerability assessment that places the community of Funafuti at the centre of the analysis to gain insight into ways in which the community is susceptible to the adverse effects of climate change. Importantly, it engages local voices and considers vulnerability to climate change in the context of stressors beyond the biophysical.

Climate change research in the Pacific Islands has focused its attention on sea-level rise, particularly as it may impact atolls. It is recognized that Pacific Islands will be impacted by climate change in a range of ways, and that these impacts will be experienced in a dynamic context, yet with the exception of a handful of studies, mostly conducted in the Solomon Islands (e.g. Fazey et al., 2011; Kuruppu & Liverman, 2011; Reenberg et al., 2008; Schwarz, 2011), work has investigated the impacts of climate change in isolation from
other stressors. This case study contributes to a broadening of the scope of research in this scholarly field; it explores the local context in the case of Funafuti, Tuvalu, finding that underlying conditions of urbanization, globalization, rapid rural-to-urban migration, overcrowding, economic hardship, land use and cover change, and cultural change are factors that contribute to both the exposure-sensitivities, and the adaptive capacity of the community. In fact, this research finds that in order to understand vulnerability to climate change, the broader context must be understood.

The key findings of this research reinforce some of the work previously done on climate change vulnerability and adaptation in the Pacific Islands region, while other insights are unique to the case study of Funafuti (summarized in Section 7.1). Certainly all insights gained in this research serve to contribute to the greater and broader understanding of experiences of change, and societal responses to change in the Pacific Islands region.

Finally, this study also makes an important methodological contribution to the field of climate change vulnerability and adaptation by illustrating the value of research methods that deliberately omit any prompted discussion on climate change (at least at first), especially in locations that have received a great deal of research and media attention with respect to climate change in recent years.

7.3 Practical Contributions

In addition to scholarly contributions, this research has practical application for future adaptation initiatives in Funafuti. Several authors have recognized that interventions which address climate change in isolation from other stressors are unlikely to enhance adaptive capacity in the long term (Barnett & Campbell, 2010, p. 14; Burton et
al., 2002; O’Brien et al., 2009; Smit & Wandel, 2006). By identifying the determinants of adaptive capacity, this research is able to identify appropriate points of intervention to enhance adaptive capacity. For example, economic hardship (i.e. high cost of living, few jobs, and low wages), and donor culture in Funafuti are barriers to adaptation, while social capital, and traditional knowledge and activities are opportunities for adaptation identified in this research. Existing capacity-building interventions, such as the donation of water tanks for individual households in Funafuti have been somewhat successful, but the longevity of this particular project is limited by the barriers of economic hardship and donor culture, which have meant that household tanks, once donated, are rarely maintained. Increasing water storage capacity of the Funafuti community remains an important aspect of enhancing adaptive capacity to water shortage.

The findings of this research suggest that social capital, manifested through a strong sense of community through the church and island community groups, as well as traditional adaptive strategies, such as sharing, represent strategic entry points for water storage capacity interventions. The construction of large cisterns beside churches and maneapas (as in the construction of the Lofeagai EKT Church cistern by the PACC project) is more likely to be successful in the long term because it avoids the constraints posed by economic hardship and the donor culture of households, and is centered on traditional systems of communal sharing.

7.4 Future Research Opportunities

The individual components of this assessment could feasibly be expanded upon to provide a more detailed characterization of community vulnerabilities. For example, the vulnerability of the local food system in Funafuti is the product of the particularly complex
interaction among a wide variety of factors, and food-related issues are problematic for most people living in Funafuti. A vulnerability assessment that focused on the food system in Funafuti and aimed to further unpack the ways in which different stressors interact would likely prove to be a fruitful analysis and provide insight into much needed entry points for interventions.

Future research opportunities also exist for vulnerability assessments in the outer islands of Tuvalu. The present community context of Funafuti is much different than Tuvalu's rural outer islands. While the way of life for Tuvaluans on all islands is changing, Tuvaluans on outer islands live more traditionally than those in the relatively modern Funafuti. Outer island communities rely more on local food than in Funafuti; therefore, life and livelihoods on the outer islands are more dependant on the land and the sea. It is hypothesized that outer island communities may be more exposed and sensitive to the impacts of climate change, but also perhaps more resilient due to the persistence of the traditional activities and adaptive behaviour. A case study of vulnerability to climate change in the context of multiple stressors in an outer island context would be necessary for the identification of appropriate points of intervention in the outer islands. Such a case study would also provide a comparison, and add context to the findings of the Funafuti case study.

This research has shown that vulnerability to climate change in Pacific Island communities is much more complex than dominant international and academic narratives describe. This is indicative of an opportunity for comparative studies to be conducted in other Pacific Island countries to document the conditions affecting communities and the strategies being employed to deal with these conditions. More empirical work that
expands the body of knowledge on the human dimensions of climate change in the Pacific Islands region would be of benefit to adaptation planning, policy, and decision-making. As international negotiations on climate change mitigation continue to be stalled, and adaptation efforts are increasingly become a necessary area of focus, such a body of literature would prove invaluable.
REFERENCES CITED


Mimura, N. (1999). Vulnerability of island countries in the South Pacific to sea level rise and climate change. Climate Research, 12, 137-143.


Schwarz, A-M., Bene, C., Bennett, G., Boso, D., Hilly, Z., Paul, C., Posala, R., Sibiti, S., and


APPENDIX 1

RESEARCH ETHICS BOARD
Certification of Ethical Acceptability of Research
Involving Human Participants

APPROVAL PERIOD: July 25, 2012 to July 25, 2013
REB NUMBER: 12JN015
TYPE OF REVIEW: Delegated Type 1
RESPONSIBLE FACULTY: BARRY SMIT
DEPARTMENT: Geography
SPONSOR: SSHRC STANDARD RESEARCH GRANT
TITLE OF PROJECT: Adaptation to Climate Change in Tuvalu

The members of the University of Guelph Research Ethics Board have examined the protocol which describes the participation of the human subjects in the above-named research project and considers the procedures, as described by the applicant, to conform to the University’s ethical standards and the Tri-Council Policy Statement.

The REB requires that you adhere to the protocol as last reviewed and approved by the REB. The REB must approve any modifications before they can be implemented. If you wish to modify your research project, please complete the Change Request Form. If there is a change in your source of funding, or a previously unfunded project receives funding, you must report this as a change to the protocol.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Responsible Faculty, the safety of the participants, and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and approvals of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

The Tri-council Policy Statement requires that ongoing research be monitored by, at a minimum, a final report and, if the approval period is longer than one year, annual reports. Continued approval is contingent on timely submission of reports.

Membership of the Research Ethics Board: B. Beresford, Ext.; F. Caldwell, Physician; C. Carstairs, COA; S. Chuang, FRAN (alt); K. Cooley, Alt. Health Care; J. Clark, PoliSci (alt); J. Devlin, OAC; J. Dwyer, FRAN; M. Dwyer, Legal; D. Dyck, CBS; D. Emslie, Physician (alt); B. Ferguson, CME (alt); H. Gilmour, Legal (alt); J. Gocertz, CME; B. Gottlieb, Psychology; S. Henson, OAC (alt); G. Holloway, CBS (alt); L. Kuczynski, Chair; S. McEwen, OVC (alt); J. Minogue, EHS; I. Newby-Clark, Psychology (alt); A. Papadopoulos, OVC; B. Power, Ext.; L. Robinson, CBS; V. Shalla, SOAN (alt); J. Srbely, CBS (alt); T. Turner, SOAN; K. Wendling, Ethics.

Approved: per
Chair, Research Ethics Board

Date: ______________________
APPENDIX 2

Participant Consent Form for Interviews

UNIVERSITY OF GUELPH

COLLEGE OF SOCIAL AND APPLIED HUMAN SCIENCES
Department of Geography

CONSENT TO PARTICIPATE IN RESEARCH
TO BE READ TO PARTICIPANTS PRIOR TO INTERVIEW

Adaptation to Climate Change in Tuvalu

You are asked to participate in a research study conducted by Sandra McCubbin and Barry Smit from the Department of Geography at the University of Guelph. Results of this project will contribute to the Masters thesis dissertation of Sandra McCubbin. The Social Sciences and Humanities Research Council of Canada is funding this research.

If you have any questions or concerns about the research, please feel free to contact Sandra McCubbin (001 519-824-4120 ext. 588570) or Barry Smit (001 519-824-4120 ext. 53279).

PURPOSE OF THE STUDY

The purpose of this study is to document the ways in which communities in Tuvalu are sensitive to the effects of climate change, and to identify possible adaptation initiatives.

PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following things:

Participate in an initial interview for 1-2 hours. Perhaps participate in a follow-up interview for 1 hour. Interviews will occur in a location of your preference. Review transcripts of interviews or notes taken during interviews to verify and confirm statements. Research findings will be shared in a community meeting at the end of the study period.

POTENTIAL RISKS AND DISCOMFORTS

There are no foreseeable risks to you from the interview process. The nature of the questions is not deeply personal.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

The community will benefit from this research by having documentation of the climate-related conditions that represent risks to the community and by identifying possible initiatives for adaptation to climate change.

PAYMENT FOR PARTICIPATION

There is no payment for your participation.
CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study unless you would like the statements you make to be attributed to you.

☐ I want my identity to be non-confidential

OR

☐ I want my identity and the information I provide to be confidential

If you would like your identity to be non-confidential, I may attribute statements you make to you in the final report of this research. If you would like your identity to be confidential, I will not refer to you directly in the final report for this research.

You may also allow me to record an audio tape of this interview, or not.

☐ I give permission for audio recording

OR

☐ I do not give permission for audio recording

All of the notes taken and the audio recordings taken for this research will be stored securely by the researcher, and only I will have access to it. Any notes taken or transcripts of audio recordings will be reviewed and confirmed with you in person.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may exercise the option of removing your data from the study. You may also refuse to answer any questions you don’t want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise that warrant doing so.

RIGHTS OF RESEARCH PARTICIPANTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through the University of Guelph Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
University of Guelph
437 University Centre
Guelph, ON N1G 2W1

Telephone: (519) 824-4120, ext. 56606
E-mail: sau@uoguelph.ca
Fax: (519) 821-5236

NAME OF RESEARCH PARTICIPANT

______________________________
Name of Participant (please print)

______________________________
Date
APPENDIX 3

Interview Guide

Name:
Age/Sex:

Recorded:

General Description

Part One: Background Information

A. How long have you lived in Funafuti?
   a) Where did you live before?
B. Do you plan on staying in Funafuti?
C. How many people live in your household?
D. What do you do for a living?
E. How do you get food?
   a) How do you get fish?
   b) Do you have a garden? What do you grow?
   c) Do you have pigs?

Part Two: Conditions affecting lives/livelihoods (unprompted)

A. What do you like about living on Funafuti?
B. What do you dislike about living on Funafuti?
C. Is there anything that happens on Funafuti that concerns/worries you?
D. Have you seen changes in Funafuti?
E. What are some of the things that have influenced your life or some of the things that
you've had to deal with over the last several years?
F. Can you remember certain years that were good or bad? What was it about those years that made them good or bad?

Part Three: Experiencing Conditions and Coping Strategies

A. How did/does it affect you? What is/was it like when it was happening?

B. How often is it a problem? How frequently has it been happening?

C. Has it always been like this? Was it like this in the past?

D. How frequently has it been happening?

E. How did you cope/deal with this?
   a) How does the community cope/deal with this?

F. Was it effective? Did it work?

G. Did you do anything to help you cope better in the future?
   a) Why not?

H. Do you think that this will continue to be a problem in the future? Are you concerned about it?
   a) Why or why not?

I. How would you cope if ________________?

J. What would make it easier to cope/deal with this? What would you need in order to do this?

Part Four: Climatic conditions affecting lives/livelihoods (prompted)

A. Have you been affected by:

Prompt with:
• Dry spells
• Extreme sea levels (flooding, salt water intrusion)
• Cyclones or strong winds
• Beach erosion
• Fish

B. Repeat line of questioning from Part Two (above).
Part Four: Experiences with water shortage

A. Where do you get your water from? Has this changed?
   a) Where and when did you get your tank?

B. What do you use water for?

C. Do you have a:
   1) Flush toilet
   2) Shower
   3) Washing machine
   4) Kitchen sink

D. How would you describe the condition of your gutters? Do they leak? Are they well maintained?

E. Do you budget your water year round?

F. Would you consider a composting toilet?

Part Five: Conclusion

What do you think are the main challenges facing Funafuti?

What things do you need to live a good life? (The life you want to live?)

Freelist favourite foods (2 minutes)