Rebuilding Sustainable Communities after Disasters

Rebuilding Sustainable Communities after Disasters:

Remote Islands

By

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To the people of the small island developing nations, who are facing the catastrophic consequences of climate change they did not cause.

"*Only after they disappear will the islands become the absolute truth of the urgency of climate change, and thus act as a prompt towards saving the rest of the planet*" (Farbotko, 2010, p47-48).

"*What kind of society creates the conditions that result in one population with the means to escape suffering and another population <u>without</u> the means to escape suffering?*" (Nickel and Eikenberry, 2007, p.538).

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PREFACE

In the South Pacific, an area prone to disasters of many kinds, tropical cyclones are predicted to increase in strength, track length and lifespan due to climate change. Small island developing states are going to need to adapt their disaster response accordingly. This is particularly the case for those communities on outer islands of these states, the remote islands within remote countries, where vulnerability is already especially high. These communities are out of reach of many aid organisations, and are required to be more self-reliant and resilient than most.

This book investigates how the responses to disasters on remote islands need to change and the factors affecting the capacity for this to happen. The research focuses on remote islands in Fiji and Tonga, from the perspectives of the communities, aid organisations and governments. It examines issues of the growth of aid, the expectations it creates, the governance of the aid system, and how remoteness impacts on disaster planning and response.

The research involved fieldwork in Fiji and Tonga, with stays on one remote island in each country. Both of these islands have a history of cyclones, including recent experience. This was followed by time in the regional and national capitals interviewing representatives of aid organisations and government. Included in the book is a reflection on the experience of doing cross-cultural research and the importance of giving voice to communities that are often left out of this kind of research.

The research found that a number of variables – such as remoteness, the highly gendered structures of decision-making, differential use of traditional knowledge, and contradictory aid expectations – directly and indirectly affect the preparedness and adequacy of remote island responses to natural disasters such as cyclones. This has a number of significant ramifications in the light of predicted transformations associated with climate change.

My sincere thanks and gratitude go to the people in both Fiji and Tonga, without whom this book would not be possible. Your warmth, generosity, enthusiasm and understanding, and the way you welcomed our family into yours, will not be forgotten. I hope this book helps your voices to reach the world.

INTRODUCTION

This book looks at the experience, expectations and perceptions of remote outer island communities in Fiji and Tonga, regarding disaster aid and climate change adaptation. It asks how similar or different these may be to the main islands, and the disaster management literature more generally, and aims to investigate how disaster responses on remote islands in Fiji and Tonga need to and are able to adapt to a changing climate. The main research questions are to identify how tropical cyclones are presently responded to in Fiji and Tonga by remote communities, aid organisations and government and; how responses might need to change in the future as climate change intensifies these events, and combines with other climate change impacts such as rising sea levels.

Climate change is bringing with it an increase in severity of natural disasters, particularly affecting small island developing states (Nurse, McLean, Agard et al., 2014; Intergovernmental Panel on Climate Change (IPCC), 2012; Deo, Ganer and Nair, 2011; Terry, 2007; Mimura, Nurse, McLean et al., 2007). This increases the need to ensure and enhance the effectiveness of responses to these disasters from all involved - governments, aid organisations, and the affected communities. While debates around the causes of climate change continue despite the strength of scientific evidence (IPCC, 2013), the impacts are not waiting for the final verdict from the politicians and policy makers. Climate change is here, and we must deal with the effects.

The costs of extreme weather events are increasing worldwide, both in terms of lives lost, and economic losses (IPCC, 2011). Sufficient evidence exists that allows us to be able to presume that disasters will increase in intensity and perhaps in frequency, over the coming years, as climate change effects such as warming ocean surface temperatures take hold (Mimura et al., 2007). Ten of the 15 most extreme weather events have occurred in the last 15 years, and disasters since 1950 have become more intense (Bettencourt, Croad, Freeman et al., 2006). Coupled with this, is the observation that natural disasters such as cyclones/hurricanes seem to be changing location and moving outside their traditional ‘zones’ (Oxfam International, 2007).

While the concrete scientific link between climate change and individual disaster events is controversial and difficult to establish for extreme weather events that occur relatively infrequently and therefore have less data available in relation to them, the overall trends are becoming clear (IPCC, 2012; Anderson, 2006). Sea level rise is being measured and documented, and is making storms more hazardous as waves and storm surges come further inland. The effects of severe weather events are being felt already, and thus, there is a need to take action now. With one in five people in the world currently living in coastal areas that are and will be affected by rising sea levels and natural disasters (McAdam, 2010), this will be a significant issue for the future. The humanitarian consequences of climate change are poorly understood and this has been identified as an area of need for research (Moriniere, Taylor, Hamza and Dowling, 2009).

Disasters used to be thought of simply in terms of the actual physical event. An extreme weather event or hazard, such as a tropical cyclone, which reaches landfall only on uninhabited islands, or an inhabited coastline but without doing any damage to infrastructure or life remains a hazard, but in what sense can the impact be considered a disaster? In more recent thinking, disasters have been defined in terms of the interaction between the event and pre-existing vulnerabilities:

> Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2012, p558).

An extreme weather event becomes a 'natural disaster' when the consequences it triggers overwhelm the capacity of the local response and seriously affect the social and economic development of a region (Ferris and Petz, 2011). If the same tropical cyclone as in the example above struck elsewhere in the world causing widespread damage beyond the capabilities of the local authorities to respond, then that hazard is considered to have become a disaster.

A hazard is:

> The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPCC, 2012, p560).

The hazard then, is the physical event that holds the potential to cause severe negative impacts, thus becoming a disaster. The extent to which those negative impacts will occur depends on the interaction of the hazard with existing vulnerabilities of the society or community in which the hazard occurs. Where the cyclone referred to above meets strong, robust, well-designed and constructed buildings, the results will almost certainly differ from if that cyclone meets already weak and flimsy shacks in a community that lacks sound infrastructure. Similarly, where the people in an affected area have somewhere strong, safe and accessible to shelter, the results will be different compared to an area where there is no safe place to be during the storm or hazard event. These differences are contained in the concept of vulnerability, which may take many forms, including that which is economic, social and political. Vulnerability is defined as:

> The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014b, p.28).

Placing the definition within the context of hazards, vulnerability is "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impacts of natural hazards" (Wisner, Blaikie, Cannon and Davis, 2004, p.11).

This refined definition of a disaster is critical, since it means that preventing disasters, or reducing the risk associated with them, becomes possible. Rather than focusing on the actual hazard event, the focus is on the underlying vulnerabilities. The definition then has meaning for the resilience and vulnerability of communities (Perry 2005). This reflects the view that disasters are social, not just natural phenomena, with humans being able to act and take decisions to reduce the likelihood of disaster or reduce the impacts (Lavell and Ginnetti, 2014). The implications of this new definition were immediately recognised as providing a guiding principle for work in this field (Quarantelli 2005).

Natural disasters may be viewed as having three phases - the evolution of vulnerability through social processes preceding the disaster, the actual disaster occurrence itself, and the response/recovery (Mutter and Barnard, 2010). For example, the construction of new dwellings on a flood plain represents the evolution of vulnerability through the social processes that led to the dwelling being constructed in a risky location. The hazard, in this case the flood, then occurs some time later, with the vulnerability meaning that for the residents the flood event may become a disaster. The final phase of the disaster is the response/recovery to the event.

This disaster response may be further divided, in temporal sequence, into emergency relief, recovery and reconstruction. Aid is provided with immediate humanitarian aid first, which may take the form of for example food, water and temporary shelter. This is followed later by recovery of livelihoods through for example the re-planting of crops, and finally the reconstruction phase that may involve the reconstruction of dwellings. The loop is complete with the next phase of the evolution of vulnerability, which may be more, less or different to the vulnerability that existed prior to the hazard event. This circular sequence of events is often referred to as the disaster management cycle - event, response, recovery, mitigation, preparedness, event (O'Brien, O'Keefe, Gadema and Swords, 2010).

The responses to climate change are often divided into two baskets - mitigation to reduce human-induced climate change, and adaptation to adjust to climate change. Of particular relevance to this study, adaptation in this context is defined as:

> The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.
>
> Incremental adaptation: Adaptation actions where the central aim is to maintain the essence and integrity of a system or a process at a given scale.
>
> Transformational adaptation: Adaptation that changes the fundamental attributes of a system in response to climate and its effects (IPCC 2014b, pp. 1-2).

There is a growing realisation of the connections between development and sustainability, and that one essential element will be to better align disaster risk reduction and climate change adaptation efforts, so as to lessen the likelihood that hazards or extreme weather events become disasters in the first place. Across the South Pacific, momentum is building for this alignment in policy (Bijay, Filho and Shulte, 2013). Alongside this shift though, there is the long held recognition that increases in expectations and dependence on disaster and development aid lead to a weakening, rather than a strengthening of resilience and self-reliance (United Nations Conference on Trade and Development Secretariat (UNCTAD Secretariat) and United Nations Disaster Relief Organization (UNDRO), 1983). Studies in indigenous communities including on small Pacific islands have shown the negative impact of disaster relief on self-reliance to be long lasting (Lewis, 2009).

Two possible and opposing effects of aid on disaster risk reduction have been proposed at a national level. There may be either:

- a preventive effect whereby the aid directly or indirectly improves preparedness,

- or a so-called ‘crowding-out effect’ with expectations of reliable aid leading to a neglect of risk reduction responsibilities (Raschky and Schwindt, 2009).

A study in Bangladesh following a cyclone in 1991 brought that concept to a community level showing that aid can lead to disaster victims losing interest in risk reduction measures (Haider, Rahman and Huq, 2006).

Fiji is experiencing an expansion of actors in its disaster aid arena, increasing the provision of aid and challenging co-ordination and governance (Fletcher, Thiessen, Willetts et al., 2013). This adds to what is already a complex disaster risk management system in a country with a noted problematic culture of dependence (Becker, 2012; Méheux, Dominey-Howes and Lloyd, 2010; Benson, 1997). Tonga does not have the same proliferation of people and organisations involved in disaster response, but also experiences difficulties with co-ordination and governance of the disaster response and aid systems, structures and bureaucracies. As the expansion moves Fiji towards what has been termed ‘competitive humanitarianism’, the interests of donors and aid organisations become increasingly important (Stirrat, 2006).

A civil society is a “non-governmental and non-profit entity that seeks to bring about positive social and environmental change…can be ‘multi-national’ and international in nature, or small grass-roots groups” (United Nations, 2010). The integration of disaster risk management and climate change adaptation strategies in the Pacific is experiencing similar difficulties with a large number of organisations involved (Gero, Méheux, and Dominey-Howes, 2010).

Bottom-up approaches, coming from the community instead of being imposed upon them, have been called for in relation to policy and disaster risk reduction, but remain uncommon (O'Brien, Bhatt, Saunders et al., 2012). This has been noted as an issue in Fiji in particular (Becker, 2012), and it is not clear to what extent these strategies filter through to remote communities. Remoteness is the product of physical distance, natural features, social processes, history, economic, politics and sociology (Gillis, 2001). Some previous studies have looked at disaster response and aid dependency in Pacific islands (Campbell, 1984) and specifically in remote island communities (e.g. Méheux et al., 2010; Campbell, 1990; McLean, Bayliss-Smith, Brookfield and Campbell 1977). Other more recent studies have addressed climate change adaptation issues, including disaster risk management in Pacific islands (Bijay et al., 2013; Barnett, 2001).

Few studies, however, bring these together to provide the perspectives of the remote island communities on issues they are at the forefront of - natural disasters and climate change. Outside of massive events such as the 2004 tsunami or Hurricane Katrina, communities are often left out of research on disaster response and climate change adaptation, and where included, they are rarely from outer, remote islands (Alam and Collins, 2010). This means that the experiences and coping strategies of those communities located furthest from aid organisation responses are often missing from research.

Coping is:

> the manner in which people act within the limits of existing resources and range of expectations to achieve various ends. In general this involves no more than 'managing resources' but usually means how it is done in unusual, abnormal and adverse situations (Wisner et al., 2004, p113).

Researchers have previously found particular resilience and coping strategies in remote places - "…the remotest parts of the north cope with floods and cyclones that in more developed parts of Australia would constitute a natural hazard or become a disaster" (King, 2007, p661). Nissology, or island studies, suggests that islands may be a good comparison point for mainlands, because they tend to enhance and exacerbate the processes and dynamics in place (Baldacchino, 2004).

This book explores how disaster responses need to and are able to adapt to the changing climate, asking in what ways adaptation may occur, and how it can meet the needs of the communities affected by the disasters. Disaster responses here, refers to the phases of relief, recovery and reconstruction. The research is set in the South Pacific, a region at the forefront of change, with high exposure to natural disasters, and high risk small island developing nations. Case studies from Fiji and Tonga are compared and contrasted, as examples informing climate change adaptation and disaster risk management generally.

OVERVIEW

In 12 chapters, the book describes the affected communities and their relationships with cyclones, the aid provided, how that aid system operates, the issue of expectations and dependence created by the aid, how remoteness impacts, and perceptions of what needs to change in the future. It examines how the adaptive capacity of remote islands is affected by current practices, and how, if at all, the governance of disaster prevention and relief is adapting to the challenges of climate change:

Chapter 1 outlines the background to the issues of cyclones, specifically in the Pacific, and the policy responses, including the linkages between disaster risk management and climate change policies at a regional and country level.

Chapter 2 provides the contextual setting for the research with the key research themes.

Chapter 3 details the methodology used in this study, and discusses methodological issues. This includes issues relevant to the qualitative ethnographical methods, and issues relating to the cross-cultural nature of this study.

Chapters 4-10 present the results from the fieldwork in Fiji and Tonga. The perspectives of the study communities, governments and aid organisations on cyclones, disaster response, climate change, what is working well and what needs to change are presented. The degree of alignment of perspectives is discussed.

- Chapter 4 details the experiences of cyclones and other natural disasters in the fieldwork locations, including normalising disasters, preparation, finding a safe place, and the immediate aftermath. This chapter is designed to set the scene of the communities in the fieldwork locations, describing the roles cyclones play in their lives, and diversity within the community, through looking at gender and faith.
- Chapter 5 discusses in detail the traditional knowledge of these remote island communities, focusing on natural warning signs of cyclones.

  The chapter provides detailed descriptions of particular signs, and notes similarities between the countries, and others in the Pacific.
- Chapter 6 focuses on experiences of disaster aid and relief, and how the system works in each country, including issues of equity

and fairness. Examples are given of the types of disaster aid received for different events over time, and the ways in which inequalities and corruption manifest themselves.

- Chapter 7 looks at governance issues and co-ordination between government and aid organisations. The types and role of various organisations involved in disaster aid are discussed, along with how the disaster management and response systems operate, and some of the practicalities involved.
- Chapter 8 looks at the expectations of aid, and dependency on aid, and the relationships between them are explored.
- Chapter 9 looks at issues of remoteness including the ways in which each of the islands in the study is remote, and how that impacts, both positively and negatively on their experiences of disasters and disaster aid, and their adaptive capacity.
- Chapter 10 focuses on perceptions of how the disaster response system needs to change to adapt to climate change. Impacts of climate change, adaptation to those impacts, and options for future adaptation are discussed.
- Chapter 11 discusses the similarities and differences between the case studies and between Fiji and Tonga, recent and forthcoming policy changes in these areas, and the relevance of this study for disaster response and recovery and climate change adaptation more broadly. The ways in which the perspectives of the participant groups (governments, aid organisations and communities) align and do not align, and what that means for adaptation and adaptive capacity is analysed. The chapter looks at how the disaster response system can adapt and how the needs of remote communities fit.
- Chapter 12 concludes with a reflection on the study and poses questions for future research.

This book will investigate the important issue of the adaptation of disaster responses to a climate changed future, focusing on remote island communities at the forefront of those disasters. It is critical to look at the adaptive capacity of the system and the responses of all involved - the communities, the aid organisations and the governments.

Acronyms and Abbreviations

ADB - Asian Development Bank
BOM - Bureau of Meteorology
CC - climate change
CCA - climate change adaptation
CSIRO - Commonwealth Scientific and Industrial Research Organisation
CSO - civil society organisation
DISMAC – Disaster Management Committee (Fiji)
DRM - disaster risk management
DRR - disaster risk reduction
FBO - faith based organisation
JNAP - Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management (Tonga)
MECC – Ministry of Environment and Climate Change (Tonga)
NDMO - National Disaster Management Office (Fiji)
NEMC – National Emergency Management Committee (Tonga)
NEMO - National Emergency Management Office (Tonga)
NEOC – National Emergency Operating Committee (Tonga)
NGO -non-government organisation
ODI - Overseas Development Institute
SLR - sea level rise
SOPAC - Applied Geoscience and Technology Division of the Secretariat of the Pacific Community
SRDP - Strategy for Disaster and Climate Resilient Development in the Pacific
UNU – United Nations University Institute for Environment and Human Security

CHAPTER ONE

CYCLONES AND THE POLICY RESPONSES

This chapter presents the background information to the problem at hand - how the responses to disasters, particularly on remote islands, can adapt to climate change. There is a focus on cyclones and the likely impacts of climate change on those cyclones in the South Pacific. This chapter locates the research sites in the broader context - the villages within the societies; the particular disasters relevant to each site within the experiences of disasters for that area and country. Following this is an outline of the key policy responses within relevant national and regional frameworks. In order to interpret the fieldwork results, the relational role of the sites within larger systems is important (Fife, 2005) and this is discussed. The chapter also provides contextual information regarding the integration of the disaster risk management and climate change adaptation policies and practices in the Pacific, including regional and national agreements and frameworks.

1.1 Tropical Cyclones in the South Pacific

A cyclone is known by different names according to where on the globe it has formed. In the western North Atlantic Ocean and Caribbean they are known as hurricanes, in the western North Pacific Ocean and China Sea they are known as typhoons, and in the western South Pacific Ocean and the Indian Ocean, they are called tropical cyclones (Terry, 2007). Whatever the terminology, a cyclone is at its most basic level a huge storm with associated strong winds and rains. They require a sea surface temperature of at least 27° Celsius to form (Deo et al., 2011) and are categorised according to the maximum sustained force of the winds by the Saffir-Simpson scale (see Table 1.1 below). Cyclones will also typically have wind gusts that are stronger than the maximum sustained wind strength used in the categorisation method.

Table 1.1: Saffir-Simpson scale for categories of cyclone strength

Saffir-Simpson Category	Maximum sustained wind speed in km/hr
1	119-153
2	154-177
3	178-209
4	210-249
5	>=250

A cyclone forms in a circular motion with an ‘eye’ somewhere towards the middle of the storm in which there is little to no wind or rain at all. Another feature that often accompanies cyclones is a ‘storm surge’. This is where violent winds and low atmospheric pressure combine to form large swells at sea. The winds increase the level of both the water and the wave height, and these swells then drive massive waves towards the shoreline, effectively piling up the sea against the shore. This leads to a temporary but rapid rise in the local sea level that typically takes about one hour to peak and another hour to fall. Near the middle of the cyclone, a storm surge can create a dome of water up to 50km across and two to five metres higher than the predicted tide height (Terry, 2007). The effects of cyclones are therefore connected with other climate change issues such as rising sea levels, as one will exacerbate the other, with higher storm surges leading to larger and more prolonged flooding, and salinsation of ground water resources.

Cyclones will usually weaken when they reach land and this is thought to be because they lose their supply of energy from the warm moist air on the sea surface. However, sometimes when the land they hit is small (such as an island in the South Pacific), they will ‘survive’, and be able to traverse the entire land mass without significantly weakening (Terry, 2007). In this way, a single tropical cyclone in the South Pacific will often affect more than one country in the region.

The Projected Impacts of Climate Change on Tropical Cyclones

It is not useful to attempt to establish a relationship between a single weather event and climatic change. However, trends over time may be discerned, and predictions made based on past knowledge of how cyclones work. In the South Pacific region, climate change is likely to lead to higher temperatures, and stronger and more persistent El Nino events (Mimura et al., 2007). Some likely impacts of this on tropical cyclones are (Terry, 2007):

- changes to the pattern of cyclone origins, with less spatial clustering and more spreading to the east than at present
- little change in the total cyclone numbers of frequency but generally more storminess east of 180^0 longitude
- increased tropical cyclone intensities, with lower central pressure and greater maximum wind speeds
- longer cyclone lifespans
- track directions tending more southerly
- extended track length and farther poleward travel before cyclone decay.

This means that while there might not be an increase in the numbers of tropical cyclones forming in the region, they may be stronger. The latest projections from the IPCC provide some support for this, in their special report on extreme weather events and disasters (IPCC, 2012). This report finds that it is likely that tropical cyclone tracks have shifted towards the poles, that the average maximum wind speed will increase, that sea level rise has resulted in increased extremely high water levels in coastal areas, and that the frequency of cyclones globally will remain the same or possibly decrease.

This special IPCC report also directly links social and economic vulnerability to the severity of impact of an event, with higher fatality rates and relative economic losses in developing countries than developed countries. It finds that development practice, policy and outcomes are critical to disaster risk, and that international efforts do not necessarily lead to improvements at the local level, because of a lack of local level data (IPCC, 2012).

The importance of integrating traditional knowledge with scientific and technical knowledge is recognised as being required to improve disaster risk reduction (DRR) and climate change adaptation (CCA) (IPCC, 2011).

Evidence and Projections in the South Pacific Region

With longer lifespans and extended track lengths, each event may impact on more islands. Both Tonga and the eastern islands in Fiji lie east of 180^0 longitude, where increased storm activity is expected.

Technology advances over time have increased the accuracy and reporting of tropical cyclone events. For this reason, increased trends in cyclone activity are sometimes attributed to these improvements rather than representing a true increase. In an attempt to address this, Deo and colleagues examined cyclones from 1977-2006, a period that is entirely post the development of satellite technology. This study found in the South West Pacific Ocean a statistically significant increase in intense cyclones and storm days in the period 1992-2006 compared with 1977-1991, and an increase in the maximum annual wind intensity over the entire period (Deo et al., 2011). This increase in the most intense cyclones in the South Pacific has been supported by other, similar studies (Diamond, Lorrey and Renwick, 2013; Kossin, Olander and Knapp 2013) and for projections accounting for climate change (Gleixner, Keenlyside, Hodges et al., 2014).

One of the factors influencing cyclone formation is the El Niño Southern Oscillation of variation on the air pressure and water surface temperatures in the Pacific. The El Niño phase is characterised by warm oceans and high air surface pressure, while the La Niña phase sees the opposite occurring, with cooler oceans and lower air surface pressure (Trenberth, Jones, Ambenje et al., 2007). In two studies concentrating on the Fiji-Samoa-Tonga region, Chand and Walsh found that in the period 1970-2006 there was an average of 4.64 cyclones per El Niño year, 2.94 per neutral year and 2.67 per La Niña year in the region (Chand and Walsh, 2009). Using the Accumulated Cyclone Energy (ACE) rating which is the square of the maximum sustained wind speed summed over the lifetime of the cyclone (a more conservative measure than the Saffir-Simpson categories), they examined cyclones in the region during El Niño and La Niña years. They found that in Fiji and Tonga, the ACE is above average during La Niña years when cyclones retain their strength for a longer period of time, compared with El Niño years (Chand and Walsh, 2011). So for Fiji and Tonga, climate change may mean more frequent cyclones during longer El Niño events, with cyclones of increased intensity during the 'quieter' La Niña years.

Countries in the South Pacific are feeling the effects of climate change and taking notice. For example, the Ministry of Environment and Climate Change in Tonga has documented the effects of climate change in Tonga: El Niño weather patterns align well with the occurrence of droughts in Tonga, there has been an increase in annual mean temperature of 0.4-0.9^{0}C since the 1970s, coral bleaching is 'becoming common', sea levels have risen 6.4mm per year since records began in 1993, and coastal erosion means that now some low lying coastal villages are inundated with tidal flooding (Ministry of Environment and Climate Change (MECC) and National Emergency Management Office (NEMO) Tonga, 2010).

The effects of cyclones in the region will be further intensified when combined with the effects of sea level rise. The average global sea level rise for the period 1962-1990 was about 1.5mm per year, but since 1990 it has been 3.2mm per year, with the increase mainly due to increases in the tropical and southern oceans (Merrifield, Merrifield and Mitchum, 2009). However, in the Pacific, the increase is far greater, with 6mm per year in Fiji and more than 6mm per year in Tonga since 1993 (Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2011). Estimates for Tonga are as high as 14mm per year since 1993 (Jayavanth, Takai and Akau'ola, 2009). In the Pacific, sea levels have been rising for over 100 years, so the effects are already evident, including inundation and erosion, and the salinisation of inland groundwater (Nunn, 2007a). Increases now being experienced in the rate of sea level rise will consequently exacerbate these and other effects.

Pacific island countries need to adapt now - faster than wealthier developed nations, but location specific predictions do not exist, nor do many solutions that have been tested elsewhere (IPCC, 2014c; Barnett, 2001). The uncertainty inherent in some aspects of climate change is exacerbated for the places experiencing the effects first. Small island developing states may be seen as barometers of how development issues such as climate change will impact communities and how to deal with those impacts (Kelman, 2011).

1.2 Fiji and Tonga

The South Pacific region is divided into Micronesia in the north west, Melanesia in the south west and Polynesia in the east. Micronesia includes the Federated States of Micronesia, Marshall Islands and Palau; Melanesia includes Fiji, Papua New Guinea, Solomon Islands and Vanuatu; and Polynesia includes Tonga, the Cook Islands, Samoa, Tuvalu, Kiribati and Nauru (Lal, Singh and Holland, 2009). The accompanying map (Figure 1) shows parts of both Melanesia and Polynesia, including both Fiji and Tonga, and their geographical relationship to each other and to Australia. Fiji and Tonga are neighbouring countries, with Tonga lying to the southeast of Fiji.

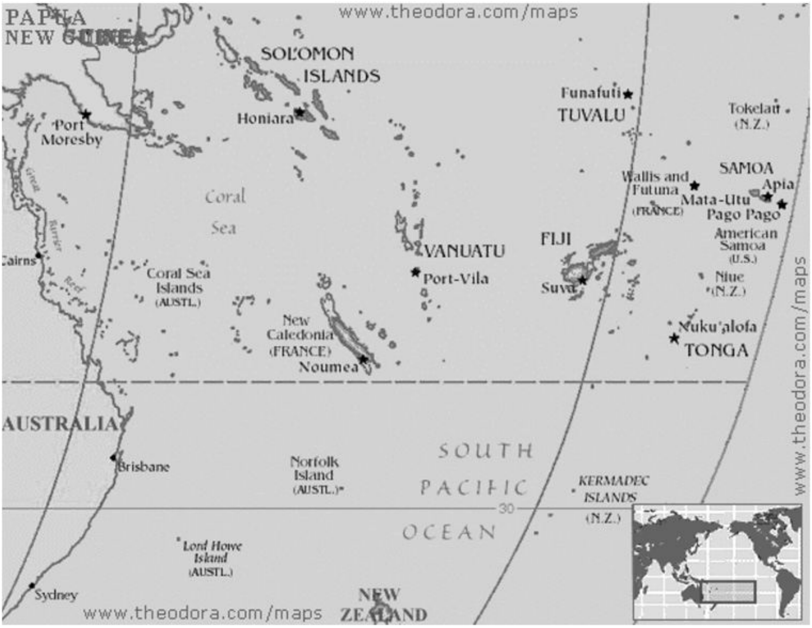

Figure 1.1: Map showing Fiji and Tonga within the South Pacific region.[1]

Fiji is a republic of less than one million people, at $18^0$00’S latitude and $175^0$00’E longitude in the Melanesian area of the South Pacific. The more than 320 islands that make up Fiji cover a land mass of over 18,000 km², and are a mixture of mountainous and volcanic terrain. The largest two islands, Viti Levu and Vanua Levu, are inhabited, along with about 100 of the smaller islands, leaving a population density of about 46 people per km².

Tonga is a small Kingdom in the Polynesian area of the South Pacific, at $21^0$12‘S latitude and $175^0$12‘W longitude, with a population of just over 100,000 people. There are 172 named islands in Tonga of which 36 are inhabited, making up an area of 649km². The islands are clustered - Tongatapu and ‘Eua in the South, Ha’apai in the middle, Vava’u in the north and Niuafo’ou and Niua Toputapu in the far north (MECC and NEMO Tonga, 2010). About half the population lives on the main island, Tongatapu, and 25% of the population live in urban areas (World Bank, 2011). All the atoll islands, and the main island which is limestone, are flat with an average altitude of two to five metres, while Vava’u, Ha’apai and

[1] Source: http://www.geographic.org/maps/new2/south_pacific_ocean_maps.html