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ADAPTATION TO CLIMATE CHANGE IN NAWAIRUKU VILLAGE, RA PROVINCE, FIJI

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Submitted to the University of the Sunshine Coast in partial fulfilment of the requirements of the degree of Masters of Arts (Geography)

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Abstract

This thesis documents and describes how people in Nawairuku village in Ra Province, Fiji, are experiencing and adapting to climate change in the context of recent socio-economic changes. The research is distinct from other climate change impacts, vulnerability and adaptation research in the Pacific Islands region in that it focuses on people living in an interior village, whereas most previous research has been conducted with people living in urban areas in the coastal zone. An analysis of data collected through semi-structured interviews with 30 villagers, participant observation, and analysis of secondary sources reveals that recent socio-economic changes are influencing how people experience and respond to climate risks. In particular, the village is exposed and sensitive to an increase in the intensity of extreme weather events, namely cyclones and flooding, with consequences for agriculture, human health and well-being, and infrastructure. Despite a long history of coping with extreme weather events, responses to recent cyclones and floods have been mostly reactionary. Land ownership, changing agricultural practices, increasing autonomy of households from the central village leadership, and aid dependency were identified as key constraints to adaptation. Entry points to support adaptation include, providing people with skills training that would enable them to collaborate with aid organisations and the government to proactively climate-proof infrastructure and agriculture in ways that are consistent with local culture and ideals while keeping pace with climate change and new standards of extremes.

Declaration of Originality

I certify that the work presented in the thesis, to the best of my knowledge and belief, is original, except as acknowledged in the text, and that the material has not been submitted, either in whole or part, for a degree at this or any other university.

I acknowledge that I have read and understood the university's rules and requirements relating to the awarding of this Higher Degree by Research and to my thesis. I have complied with these.

Renee Currenti
April 2018

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Contribution of Authors

This thesis includes two drafted manuscripts that contribute to addressing the identified research gaps, questions and objectives. Due to this structure and the need for individual papers to set their own context to exist as stand-alone documents, there is a level of redundancy between some chapters of the thesis and sections of the manuscripts. In particular, the introduction and case study sections of both manuscripts are similar due to both being based on the same data. Likewise, some of the content of chapters three (case study) and four (methods) is repeated in the methods section of the first manuscript (chapter five). Despite this repetition, the body of the thesis tells a coherent story that answers the research question.

The first manuscript is titled 'Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji'. This manuscript describes the research approach and methods used, and the findings of the research. The second manuscript is titled 'Preparing for, experiencing and responding to cyclones and floods in Nawairuku, Ra, Fiji'. This manuscript builds upon the first manuscript and focusses on how the village prepared for, experienced and responded to two recent extreme weather events, a cyclone and an extreme flood.

Both manuscripts are co-authored by Dr Tristan Pearce (University of the Sunshine Coast), Prof Roy Sidle (University of the Sunshine Coast), and Dr James Ford (University of Leeds). I was primarily responsible for data collection and analysis, and the preparation of the manuscript. Dr Pearce and Dr Ford offered guidance and insights early in the data collection process. In drafting the manuscript Dr Pearce provided me with significant feedback and guided me on important elements of the framing and content. Prof Sidle and Dr Ford provided me valuable feedback and guidance at various stages of the writing process. Teresia Salabogi, Kiniviliame Salabogi, Roger Kitson and Brendan Doran made significant contributions to the research and will be invited as co-authors for the purpose of publication post-thesis submission.

The first and second manuscripts are in review in *Human Ecology* and *Disasters* respectively. Responsibility for any issues, errors, or omissions in either manuscript or the thesis falls entirely on me.

** Signed copy as Appendix 9 **

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List of Acronyms

AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
AusAid	Australian Aid
CCF	Community Capitals Framework
ENSO	El Niño-Southern Oscillation
HDCC	Human Dimensions of Climate Change
IPCC	Intergovernmental Panel on Climate Change
IVA	Impacts, Vulnerability, Adaptation
NGO	Non-Governmental Organisation
PAR	Pressure and Release
PDO	Pacific Decadal Oscillation
RCP	Representative Concentration Pathways
SLA	Sustainable Livelihoods Approach
SLR	Sea Level Rise
SPCZ	South Pacific Convergence Zone
SSP	Shared Socio-economic Pathways
TAR	Third Assessment Report
TC	Tropical Cyclone
TEK	Traditional Ecological Knowledge
TRM	Talanoa Research Methodology

Glossary of Fijian terms and references

Bolabola	Temporary shelter or shed often made for occasions when many people will assemble
Bilibili	Raft made of lashed-together bamboo and steered with a long pole that is pushed down to the riverbed. In shallow waters, the raft is moved by men wading in the water behind it and pushing
Breadfruit	*Uto Artocarpus altilius.* The fruit serves as a staple food in Fijian and other Pacific cultures. The fruit, when cooked, has a texture of bread and has a potato-like flavour
Bula Vakavanua	The traditional Fijian way of life
Bure	Traditional Fijian house
Carrier	3-tonne (or 1-tonne) Isuzu truck used for passenger and cargo transport around Fiji
Cassava	Also known as Tapioca. *Manihot esculenta*. A staple food and cash crop. Cassava roots are long and tapered, rich in starch, and are consumed daily in Fijian villages
Dalo	Also known as taro. *Colocasia esculenta*. A staple food and cash crop. Dalo tubers are round and starchy, like a potato
Duva	*Pittosporum sp.* Plant used to poison fish. Roots are pounded and placed in a cloth-like sack and waved in the water
iTaukei	Indigenous Fijians
Jaba	Pr. Chamba Traditional Fijian dress for females
Kava	The beverage of yaqona roots mixed with water
Kerekere	The Fijian custom of willingly giving with no expectation of repayment (e.g. when a relative or neighbour requests something that is needed)
Koro	Village
Kumala	Also known as sweet potato. *Ipomoea Batatas,* A staple root crop
Mataqali	A sub-clan; subdivision of a *yavusa*
Maleya	Also known as tilapia. *Oreochromis niloticus.* Freshwater fish found, and commonly caught in interior rivers. Important source of protein, especially for interior populations
Provincial Council	The governing body of each province (*yasana*). The administration body between villages and upper government
Rourou	The leaves of the dalo plant. *Colocasia esculenta*. Prepared by boiling in coconut milk. Good source of protein
Sevusevu	A *yaqona* presentation made when something is requested
Talanoa	To tell/a tale or story/dialogue/a research methodology
Tikina	District
Tokatoka	The enlarged family unit
Turanga-ni-koro	Village headman
Uvi	Also known as yam, *Dioscorea sp.* Edible tuber. Considered a staple in the Fijian diet but less-cultivated in Nawairuku
Vanua Levu	The second largest island in the Republic of Fiji, located 64 kilometres north of Viti Levu
Viti Levu	The largest island in the Republic of Fiji, the island of the nation's capital, home to 87% of Fijian population. *Viti Levu* translates to "Great Fiji"
Vudi	Also known as plantain. *Musa sapientum*. A cousin of the banana. Used in savoury and sweet dishes and a common cash crop in Nawairuku
Waka	The dried roots of the *yaqona* plant
Yaqona	*Piper methysticum*. Cultivated shrub. Pounded roots are used to infuse as a ceremonial and social beverage (*Kava*)
Yasana	Province

Chapter 1: Introduction

1.1 Research rationale

The Pacific Islands region is widely regarded as a "hot spot" for global climate change with countries often referred to as 'canaries in the coalmine' (Mimura et al., 2007; Benwell, 2011; Farbotko and Lazrus, 2012). Biophysical changes including sea-level rise, coastal erosion, ocean acidification and increasing water and surface air temperatures have already been recorded and are expected to continue, and accelerate, in the future (Burkett et al., 2014; Nurse et al., 2014). The risks of climate change are significant, challenging human rights, livelihoods, health, and well-being, and food security (Barnett and Campbell, 2010). Adaptation, being unavoidable, is already underway so negative impacts can be moderated and opportunities captured (Ford et al., 2015).

To date, most climate change research in the Pacific Islands region has focused on measuring biophysical changes, with less known about how these changes translate to affect the lives and livelihoods of people and their capacity to adapt. Other research has projected potential future climate change impacts using climate models and future emission scenarios (McIver et al., 2016; Carson et al., 2016; Hanich et al., 2018). When the human system is considered in these studies it is usually done so at the end of the study, with vulnerability measured as a residual of projected impacts minus assumed adaptations (Woodward et al., 1998; Nunn, 2013). This research has advanced our broad understanding of how people living in the Pacific Islands region might experience and respond to future climate change, but it has limited use for advancing adaptation at the community scale.

While many studies about changes in biophysical systems are made at large scales, human activity is highly localised, and impacts and responses will be conditioned by local geography and a range of societal factors, including economic trends, diversity of food systems, and experience with "change" (Duerden, 2004). This requires case study research conducted at local and community scales and the inclusion of local people to identify what climate conditions are relevant and important to them and what adaptations are realistic and desirable (Ford et al., 2010). To initiate adaptation, decision makers need to know the nature of vulnerability, in terms of who and what are vulnerable, to what stresses, and in what way, and the capacity of the system to adapt (Smit and Wandel, 2006; Pearce et al., 2010). In the climate change field, 'vulnerability' refers to the susceptibility of a system to harm relative to climatic stimuli and relates to both sensitivity to climate exposure-sensitivities and the capacity to adapt (Adger, 2006; Smit and Wandel, 2006). Recent vulnerability assessments acknowledge that climate change is being experienced in the context of existing social, economic, political and environmental stressors that influence exposure-sensitivities and adaptations (Adger, 2006; Field et al., 2014; Reed et al., 2013). It is also agreed by many that adaptations are most effective when *mainstreamed* with existing disaster preparedness and resource management initiatives (Huq et al., 2003; Klein et al., 2007).

Research that has examined vulnerability to climate change in the Pacific Islands region at local scale has most often done so with people living in urban or near-urban areas (Sutherland et al., 2005; Mortreux and Barnett, 2009; McCubbin et al., 2015). Here, vulnerabilities to changing climatic conditions are evident in land, food and water resources through the interaction of non-climatic forces (overcrowding, urbanisation, few economic opportunities, changing land use, and shifting cultural norms), and climatic forces, namely dry spells, sea level rise, strong winds and changing marine conditions (McCubbin et al., 2015). Reported adaptations have been mainly reactive and short-term, and sometimes maladaptive in the longer-term (Barnett and Chamberlain, 2010; McCubbin et al., 2015; Santha, 2015). Less is known about the experiences of people living in geographically remote locations, particularly rural, inland areas. It is surmised that people living in geographically remote locations in the Pacific Islands region experience and respond to climate change differently due to the sensitivity of traditional livelihoods to environmental change (e.g. fishing, farming, shellfish gathering) and the role that traditional governance plays in adaptation.

Existing studies point to some important questions: *How* are people living in geographically remote locations in the Pacific Islands region experiencing and responding to climatic changes? *How* do traditional systems of environmental governance facilitate or impede climate change adaptation? *What* role, if any, does traditional ecological knowledge play in adaptation? *How* do the experiences of people living in geographically remote locations compare to the experiences of people living in urban or near-urban locations? Finally, *can* this information contribute to more relevant, desirable and equitable support for climate change adaptation in the Pacific Islands region?

The research responded to these knowledge needs and **aimed to examine how people living in a geographically remote location in Fiji's interior are experiencing and responding to climate change through a case study of Nawairuku village, Ra Province.** The aim was achieved through three objectives:

1. **Document the conditions that currently affect the livelihoods of people living in Nawairuku village.**
    - In the context of this research, "conditions" refer to the circumstances or factors that affect the well-being of people (e.g. exposure-sensitivities). In particular, it refers to those that contribute to hardships, make life difficult, or stress livelihoods.

2. **Characterise the adaptive strategies employed to manage and cope with these conditions**
    - This research particularly focused on the role of traditional systems of environmental governance and traditional ecological knowledge in facilitating or impeding adaptation.

3. Describe factors that aid or constrain adaptation

- This research explored the internal and external forces that may facilitate or inhibit adaptation efforts within the system, including forces identifiable by the community as well as the agendas and priorities of NGOs, governments and aid providers.

This research is novel in that it (i) does not pre-suppose climate change to be a condition affecting people's lives, but rather lets community members identify what conditions are relevant and important to them and determine adaptive strategies that are realistic, feasible and desirable; (ii) assesses vulnerability to climate change in the context of multiple climate and non-climatic stressors; and (iii) focusses on a geographically remote non-urban, non-coastal setting.

1.2 Thesis organisation

This thesis is organised into seven chapters, with the *Introduction* being the first. Chapter two, *Literature Review*, provides a synopsis of relevant literature to situate this research within four relevant bodies of scholarship, as well as identify knowledge gaps. Chapter three, *Case Study*, provides the local and regional context for the research case study. Chapter four, *Methods*, establishes the research design and approach, and describes what methods were used to apply the conceptual framework to the case study community. This chapter also outlines the methods for data collection and data analysis. Chapter five is the first of two manuscripts and is titled '*Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji*'. This manuscript describes the research approach and methods used, and the findings of the research. The manuscript responds to the three research objectives and discusses the significance of the research findings to expand the current narrative of climate change impacts, vulnerability and adaptation in the Pacific Islands region beyond the coastal zone to include the experiences of people living in the interior. Chapter six, the second manuscript is titled '*Preparing for, experiencing and responding to cyclones and floods in Nawairuku, Ra, Fiji*'. This manuscript builds upon Chapter 5 and focusses on how Nawairuku prepared for, experienced and responded to two recent extreme weather events, a cyclone and an extreme flood. Again, this manuscript discusses the significance of research findings and, through the lived experiences of people in Nawairuku, illustrates that proactive efforts to build resilience within the system are needed to lessen the impact of future hazard events. Chapter seven, *Conclusion*, ends the thesis, providing a synopsis of key research findings, a summary of scholarly and practical contributions, and suggestions for future research opportunities.

Chapter 2: Literature Review

This research engages with climate change impacts in the Pacific Islands region, the concepts and operationalisation of vulnerability and adaptation and ways of assessing each within a climate change context, human dimensions of climate change (HDCC) research in the Pacific Islands region, and traditional ecological knowledge (TEK). These bodies of scholarships are reviewed and critiqued to identify knowledge gaps and opportunities for research.

2.1 Biophysical impacts of climate change in the Pacific Islands region

Pacific Island countries are exposed to a range of climate change impacts, many which have been documented and are expected to continue, and sometimes amplify, in the future (Nurse et al., 2014). Spanning an area of 30 million km^2, the twenty-three countries and territories and thousands of islands that form the South Pacific Island countries vary immensely by typology (landforms, geomorphology, tectonics and volcanic activity and coastal features), climate, culture, level of economic and infrastructural development and demographics (Paeniu et al., 2015). Each of these aspects play a role in determining the degree to which communities are exposed and sensitive to harm from certain climate change impacts (Smit and Wandel, 2006; McCubbin et al., 2015). For instance, low-lying coral islands and atolls (Kiribati, Marshall Islands, and Cook Islands) are far more susceptible to harm from rising sea levels and storm surges than large continental, mountainous islands such as Viti Levu and Vanua Levu of Fiji and New Britain of Papua New Guinea (Forbes et al., 2013). The 'smallness' and geographical isolation of many islands or inland communities in the Pacific Islands region is likely to contribute to different sensitivities to changing environmental conditions compared with communities on larger islands. This may be due to difficulties in accessing goods and services including mainstream health, education, energy supply, and other public and private services (Maru et al., 2014).

2.2.1 Sea level change

Sea level rise is the most widely documented physical impact of climate change in the Pacific Islands region (Mimura, 2013). Global sea level rise (SLR) is attributed to two dominant causes which explain 75% of observed global mean SLR: glacial melt and thermal expansion (Church et al., 2013). It is very likely (90-100% certainty) that both causes are directly influenced by anthropogenic forces (CO_2 emissions) and are exacerbating the issue of SLR at a global scale (Hartmann et al., 2013). During the 20th Century the global mean sea level rose at a rate between 1.3 and 1.7mm yr^{-1}(Church et al., 2013) It is recognised that this rate is not uniform across the globe with parts of the tropical Western Pacific observing a rise at four times this rate (≈12mm yr^{-1}). Such rates were recorded in seas surrounding Palau and the Federated States of Micronesia (latitude 10°N) as well as

the Solomon Islands (latitude 10°S) between 1993 and 2009 (Nurse et al., 2014). It is these regions that are enduring disproportional effects of SLR. Natural, periodic and regional fluctuations of sea levels in the Pacific are attributed to ocean current processes of El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) (Salinger et al., 1995; Nurse et al., 2001). Naturally occurring fluctuations are known to have caused localised inundation of low-lying islands and coastlines across the globe in the past. Documented impacts of sea level rise in the Pacific Islands region include, inundation, shoreline change and saltwater intrusion into underground aquifers. The Intergovernmental Panel on Climate Change (IPCC) has stated it is virtually certain that global mean SLR will continue beyond 2100 with thermal expansion continuing for many centuries (Church et al., 2013).

2.2.2 Changing precipitation regimes (floods and drought)

Changes in seasonal precipitation regimes have been documented on a global (Hartmann et al., 2013). Globally, there has been an observed increase in heavy precipitation events, and increases and decreases in droughts depending on regional context (Hartmann et al., 2013). Similar to changing sea levels, rainfall patterns in the Pacific Islands region are closely tied to natural climate variabilities associated with ENSO and PDO. It is crucial to recognise the close relationship between the routine movement of the South Pacific Convergence Zone (SPCZ) and seasonal rains. Pacific Island countries experience changing rainfall regimes depending on their location relative of the SPCZ. A shift in rainfall seasons results in unseasonal and prolonged periods of drought as well as periods of intense rain. A recent trend has been observed of increased rainfall northeast of the SPCZ (Kiribati, Tuvalu, etc.) and decreased rainfall southwest of the SPCZ (Vanuatu, Fiji, Tonga, etc.) (Australian Bureau of Meteorology and CSIRO, 2011a; Kumar et al., 2014). Alterations to the hydrological cycle in times of droughts and floods effects water quantity and quality, with negative implications for human health (Feresi et al., 2000; Hoeke et al., 2013).

2.2.3 Changing tropical cyclone patterns

Understanding changes in extreme climatic events is vitally important due to the severe impacts they inflict on societies and ecosystems (Hartmann et al., 2013). A consensus has not been made regarding the projected behaviour of cyclones in a warming climate, however, modelled predictions show cyclone frequency is likely to decrease or remain unchanged while intensity (precipitation rates and maximum wind speeds) is likely to increase (Nurse et al., 2001). Increasing severity of cyclone events contributes to the risk of greater damage being inflicted upon coastal and interior ecosystems and societies. Cyclonic waves and winds contribute to accelerated coastal erosion of exposed coastlines while saturation of inland slope soils encourage landslides and floods (United States Geological Survey, 2004; Leon et al., 2015).

2.2.4 Increased land and sea surface temperatures

Global average sea surface temperatures (SST) and global mean surface temperatures have increased since the beginning of the 20th century and end of the 19th century (Hartmann et al., 2013). Globally, hot days and nights have increased while cold days and nights have decreased (Hartmann et al., 2013). The last three decades (1980s, 1990s and 2000s) have witnessed the warmest global land and sea surface temperatures in recorded history. Similarly, the Pacific Islands region's warmest recorded years have occurred in the past two decades and the past five decades have warmed +0.08-0.20°C per decade (Australian Bureau of Meteorology and CSIRO, 2011a; Kumar et al., 2014). Global temperature increases are regionally disproportionate and the rate of increase in the Pacific region is lower than the global rate due to the higher proportion of ocean cover, which is known to increase slower than land cover (Australian Bureau of Meteorology and CSIRO, 2011a). Average SST in the tropical Pacific warmed by 0.7°C from 1950 to 2000 (Hartmann et al., 2013). Rising SST has prompted observed poleward species migrations as marine species relocate from warming equatorial waters, following the poleward distribution of respective habitable conditions (Doney et al., 2012; Madin et al., 2012; Marzloff et al., 2016). The poleward relocation of species contributes to biodiversity decline and potentially limits the availability of marine resources available for harvest for daily sustenance (Mimura et al., 2007).

2.2.5 Warming and acidification of coastal waters

Increase in sea surface temperature and acidity through absorption of CO_2 has led to reef degradation through coral bleaching, encouraging mortality and decreasing the constructional ability of corals (Nurse et al., 2014). The degradation of coral reefs subsequently results in loss of structural integrity and shoreline protection characteristics, in turn, exacerbating shoreline erosional processes (Wong et al., 2014; Kench and Owen, 2015). Mass coral bleaching events have been documented over the past 30 years commonly followed by mass mortality of the respective coral reef ecosystem, due to both ocean warming and excess nutrients and sediment loads from land management practices (Wong et al., 2014). Ocean acidification decreases calcification, jeopardising the ability of a coral reef to rebuild. Coral reef ecosystems support an abundance biodiversity, providing food and shelter to many marine species that many, if not all, Pacific Islanders depend on for subsistence fishing for food intake (Moberg and Folke, 1999). Extensive coral bleaching was documented in Hawaii in November 2015, in Fiji and New Caledonia in February 2016 and in the Great Barrier Reef along the north-east coast of Australia in mid-2016 following a rapid warming of surrounding ocean temperatures (Normille, 2016; Pendleton et al., 2016). Similarly, a massive die-off of 7,000 ha of mangrove forests was recorded along a 700 km stretch in the Gulf of Carpentaria in north Australia in mid-2016, which coincided with the coral bleaching event in the Great Barrier Reef caused by the unusually warm waters (Slezak, 2016). The destruction of reef and mangrove ecosystems reduces the services they

provide to the communities that depend on them – provisioning, tourism and fishing income, and protection from storms, waves and open sea swells (Hernández-Delgado, 2015; Paeniu et al., 2015).

2.2.6 Saltwater inundation and intrusion

Land inundation associated with SLR threatens coastal communities, particularly of island nations (Seneviratne et al., 2012). Cases of inundation have been observed in numerous locations across the Pacific Islands region. Low-lying communities of Torres Islands, Vanuatu, and many across Papua New Guinea and Solomon Islands have endured episodic or permanent inundation attributed to forces such as heavy, unseasonal rains or extreme storm events, tectonic subsidence, high regional sea levels linked with ENSO and ongoing SLR (Ballu et al., 2011; Hoeke et al., 2013). Research conducted in the Solomon Islands using time series aerial and satellite imagery coupled with local historical insights recently identified five vegetated reef islands that have been completely inundated since the late 1940s due to SLR and increasing wave exposure (Albert et al., 2016). Inundation events are bound to worsen as increasing mean sea levels will amplify the effects of natural events (tectonic movements and ENSO). Coastal inundation has the potential to drastically alter and erode shorelines, damage infrastructure and property, and force low-lying islands and atolls into inhabitability by contaminating underground water resources and destroying food crops and arable land (Barnett and O'Neill, 2011).

2.2.7 Agricultural productivity

Current climatic changes have already negatively affected local agricultural systems with implications for food security, subsistence, and income (Nelson et al., 2009). Localised environmental changes effect soil fertility, moisture content, crop yield and overall agricultural productivity (Morton, 2007; Nelson et al., 2009). For example, short-run crop failures and long-run production declines are likely in response to changing precipitation patterns (Nelson et al., 2009). Degraded agricultural land and lower productivity has been observed across the Pacific Islands region and this trend is projected to continue under future climate change (Barnett, 2001). In response to lower soil productivity, some small-scale farmers have started to use agrochemicals to increase production and yields, with possible negative impacts on human health (Boxall et al., 2009). The long-term and flow-on effects of intensive agrochemical use is unknown and may threaten sustainable agricultural practices, freshwater sources, aquatic life and human health (Fianko et al., 2011; Magauzi et al., 2011; Kovács-Hostyánszki et al., 2017).

2.2 Vulnerability and Adaptation

2.2.1 Definitions and conceptualisations

Vulnerability

The term 'vulnerability' originates from the early 17th century, derived from the Latin *vulnerabilis*: to wound. Framing this to its current interdisciplinary meaning, vulnerability describes the 'capacity to be wounded' (Kates, 1985). The concept of vulnerability stems from the risks and natural hazards literature reflecting how physical impacts of disasters translate to affect societies. Some scholars identified a limitation in this conceptualisation of vulnerability: it ignores the agency owned by the people within of the effected system that conditions how people experience and respond to risk (Davis, 1981; Timmerman, 1981; Wisner, 1988; Maskrey, 1989). Stemming from research on poverty and famine, Chambers (1989) acknowledges the two 'sides' of vulnerability – the *external* side of risks, shocks and stress which is placed upon a system; and the *internal* side of inadequacy to cope with these external forces. Similarly, Sen (1981) and Watts and Bohle (1993) acknowledge the power of endogenous features of a system in determining vulnerability or resilience in their work on famine in sub-Saharan Africa. Vulnerability in poverty and famine literature refers to the existence of risks (internal and external) that pose large-scale entitlement deprivation (Sen, 1990) and without access to certain entitlements populations are more likely to fall into a state of poverty, increasing the vulnerability of the whole system (Downing, 1991). Entitlements are the actual or potential resources available within a system (Adger, 2006). This *entitlement theory* focuses on the level of access to resources which, when protected and promoted, increase the capability to secure basic needs.

The use of vulnerability in the climate change field builds upon the risks and natural hazards, geography, and famine scholarships, and considers vulnerability as a function of the ways in which a system (e.g. human community) is exposed and sensitive to changing environmental conditions (e.g. climate risks) and the capacity of the system (human or natural) to cope, adapt or recover from the effects of those conditions (Ford and Smit, 2004; Adger, 2006; Smit and Wandel, 2006). Duerden (2004) notes that while many prognoses about climate change are made on a large scale, human activity is highly localised, and impacts and responses will be conditioned by local geography and a range of endogenous factors, including the physical location and geography, demographic trends, economic complexity, and experience with change. Expressed formally in climate change research, vulnerability (V) of a community (*i*) to stimulus (*s*) over time (*t*) is a function of the relative exposure (E) and sensitivity (S) to (*i*) and capacity to adapt (A) (Figure 2.1) (Smit and Pilifosova, 2003).

$$V_{ist} = f\,(E\text{-}S_{ist}, A_{ist})$$

Figure 2.1 *Smit and Pilifosova's model of vulnerability*

Exposure-sensitivity put simply is the susceptibility of people and communities to variable conditions (Smit and Wandel, 2006). *Exposures* are the climatic and non-climatic stimuli that a

system could potentially experience which Chambers (1989) referred to as external forces (Ford and Smit, 2004). *Sensitivity* is the degree to which a community is susceptible to harm from a given exposure. *Adaptive strategies* are actions taken to increase the *adaptive capacity* of the system which is the potential or ability to address, plan for, or adapt to exposures – the internal forces that influence the ability of the system to cope with the external forces (Ford and Smit, 2004; IPCC, 2014a).

Adaptation

The use of the term adaptation in climate change research follows suit of its use in ecology and social sciences where it refers to the behavioural or structural changes and adjustments by which an organism, species or socio-economic system becomes fitted to its environment (Smit et al., 2000). In the climate change scholarship adaptation is "*the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities*" (IPCC 2014a, p. 1758). In the context of human dimensions of climate change Smit and Wandel (2006) define adaptation as the processes or actions taken in a system to better cope with, manage or adjust to some kind of changing condition – either climatic or non-climatic. All changes result in vastly different impacts on different groups in society depending on geographical location, exposure and sensitivity to risk, and use of and access to resources (Adger, 2006). Adapting to climate change impacts on local scales requires understanding the state of a particular system, both in terms of exposure and sensitivity to harm and capacity to adapt.

Coping strategies or mechanisms are short-term responses employed that temporarily reduce the vulnerability of a system to external stresses (Turner et al., 2003). Such strategies include relying on external assistance, sharing the burden through food sharing and sending/receiving monetary remittances and construction of coastal barriers (McCubbin et al., 2015). Key characteristics distinguish coping strategies from adaptation strategies summarised by Dazé et al. (2009) (Table 2.1). The continual application of coping mechanisms, in some cases, can give way to longer-term adaptation strategies where actions have a longer-term effect with sustainable outcomes. Berkes and Jolly (2001) highlight that coping and adaptive strategies are continuous along the temporal scale with feedback between the varying levels of responses.

Table 2.1 *Characteristics of 'coping' and 'adaptation' strategies*

Coping	*Adaptation*
• Oriented towards shorter-term and immediate survival • Not continuous • Motivated by crisis; reactive • Often degrades the resource base • Prompted by a lack of alternatives	• Oriented towards longer-term livelihood security • A continuous process • Results are sustained • Uses resources efficiently and sustainably • Involves planning • Combines old and new strategies and knowledge • Focused on finding alternatives

Response to change occurs at varying temporal and spatial scales and via a variety of processes taking many forms with differing intentions (Smit et al., 2000; Biagini et al., 2014). Typologies of adaptation activities have been categorised into five classifications adapted from the findings of Smit et al. (2000), Berkes and Jolly (2001), and Smit and Skinner (2002) (Figure 2.2). Based on the timing of adaptive action relative to the stimulus, adaptations may be *reactive*, *concurrent* or *anticipatory* (Smit et al., 2000). Based on the intent of implementation with respect to the stimulus, adaptations may be *autonomous* (spontaneous actions) or *planned* (intentional and deliberate) (Smit et al., 2000). Adaptations occur at a variety of spatial scales from highly *localised* actions decided by individuals or *households* to widespread actions facilitated by international organisations (Smit et al., 2001; Smit and Skinner, 2002). Adaptation activities exist in many forms: technological, behavioural, structural, financial, institutional or informational (Smit et al., 2000; Smit and Skinner, 2002; Fidelman et al., 2013). Adaptations can *incrementally* respond to smooth or gradual change or in a *transformational* manner responding on a much larger scale or intensity which are new to a particular region or system which will transform places (Smit et al., 2000; Kates et al., 2012; Biagini et al., 2014).

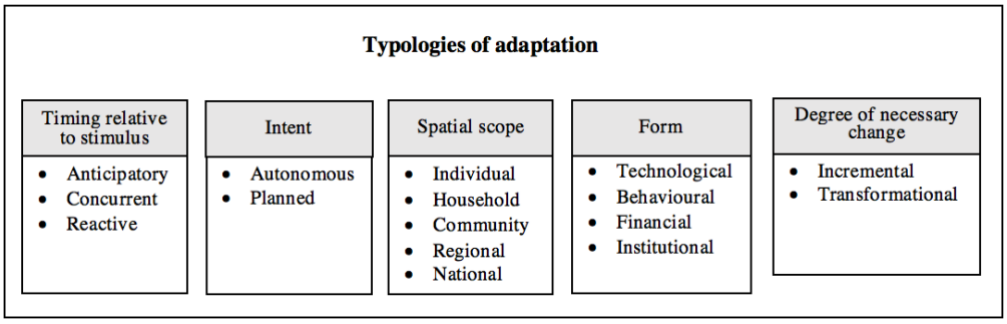

Figure 2.2 *Typologies of adaptation*
Adapted from Smit et al., 2000; Berkes and Jolly, 2001

Adaptation strategies increase the coping range of a system to accommodate deviations from 'normal' conditions (Smit et al., 2000; Smit et al., 2001; Sidle et al., 2013). The coping range of a system is the adaptive capacity of that system to deal with the current set of conditions and may change reflecting new adaptations in the system. The coping range may be narrowed by factors including population pressure or resource depletion over time while economic growth or improvements in technology or access to resources can increase adaptive capacity, broadening the coping range (Smit and Wandel, 2006). Conditions occurring within the system's coping range are relatively tolerable, however the cumulative occurrence of impacts (either natural or human-induced) near the coping range limit can decrease the threshold beyond which the system cannot cope nor recover from (Smit and Wandel, 2006; Sidle et al., 2013). The increasing frequency of events one step beyond the coping threshold pushes the system over a tipping point which, when crossed, can result in a catastrophic collapse of processes or functions that are difficult to restore (Sidle et al., 2013).

While some adaptations may broaden the coping range of a system and the ability to absorb external stresses, some adaptation efforts have the opposite effect. These actions are termed *maladaptive* and though their implementation may have had good intentions, they create a separate concern (either current or future) requiring addressing. IPCC defines maladaptation as *"an adaptation that does not succeed in reducing vulnerability but increases it instead"* (2001, p. 378). Prime examples of maladaptation in Pacific Islands region coastal areas is the reclamation of low-lying land and construction of coastal defence mechanisms by means of hard engineered sea wall, groynes and causeways (E.g. sand mining in the Marshall Islands and construction of defence mechanisms in Tarawa Atoll, Kiribati (Ford, 2012a; Duvat, 2013)). These interventions are known to alter ecosystem dynamics by interrupting natural movement of sediment creating further implications for the system.

Adaptations to climate change are most effective when mainstreamed to address multiple stressors and existing problematic conditions (Huq et al., 2003; Klein et al., 2007; Pearce et al., 2010; Berrang-Ford et al., 2011). Mainstreamed efforts increase financial, health, educational and cultural capacity in the community which inadvertently increases the adaptive capacity of the community to deal with current and future climatic and non-climatic risks (Pearce et al., 2010).

2.2.2 Models, frameworks and approaches

Several analytical frameworks for operationalising the concept vulnerability in climate change adaptation research have been proposed, including the (i) impact based approach (Smit et al., 2001), (ii) pressure and release (PAR) model (Hewitt, 1998; Wisner et al., 2003), (iii) sustainable livelihoods approach (SLA) (Krantz, 2001; Reed et al., 2013), and (iv) vulnerability approach (Ford and Smit, 2004; Smit and Wandel, 2006) (Table 2.2).

Table 2.2 *Common frameworks, models and approaches for assessing vulnerability*

Model / approach	*Emerged from:*	*Key characteristics*	*Key players*
Impact-based approach	Disaster Response Management	• Broad scale • Uses projections to form scenarios to deduce potential impacts (Westerhoff and Smit, 2009)	Kelly and Adger (2000); Smit et al. (2001); Cutter et al. (2008)
Pressure and release (PAR) model	Risks and natural hazards	• Identifies the societal processes that generate vulnerability as well as the event leading to the physical exposure to a hazard (Hewitt, 1998)	Hewitt (1998); Turner et al. (2003); Wisner et al. (2003)
Sustainable Livelihoods Approach (SLA)	Poverty alleviation; sustainable development	• Stemmed from poverty alleviation research • Identifies community assets that are both 1) affected by disasters or hazards; and 2) a means of increasing community resilience	Krantz (2001); Flora et al. (2004); Emery and Flora (2006); Reed et al. (2013)
Vulnerability approach	Human dimensions of climate change	• Humans in the system have agency to alter the state of vulnerability (Hewitt, 1998)	Ford and Smit (2004); Smit and Wandel (2006); Westerhoff and Smit (2009)

2.2.2.1 Impact-Based Approach

Also referred to as scenario-based approaches, impact-based approaches assess vulnerability to climate change by imposing projected climate variations on a set of societal settings and conceptualising how the projected climate scenario will affect an ecosystem or society on a long-term (Füssel and Klein, 2006). Using projected scenarios allows for exploration of hypothetical long-term socioeconomic and environmental consequences (van Vuuren et al., 2014). Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs) are the two key elements that comprise a scenario framework and which potential impacts are based upon.

This approach is conventionally top-down, identifying and quantifying the potential effects of impacts on ecosystems and societies (Smit and Pilifosova, 2003). This approach, however, has little involvement with stakeholders, does not incorporate the capacity of human agency in applying adaptation efforts and has little consideration of non-climatic factors affecting the system (Füssel and Klein, 2006). The impact-based approach assumes direct cause and effect of climatic variants on a system without consideration of societal conditions that alter the level of vulnerability (Kates, 1985). Climate change impact studies have improved our understanding of the potential severity of the broad effects of climate change on ecosystems, but they do not explicitly address the consequences of these impacts for society including the agency to adapt (Pearce et al., 2010).

2.2.2.2 Pressure and Release (PAR) model

In the risks and natural hazards literature, the Pressure and Release (PAR) model is commonly operationalised to assess the influence of root causes, dynamic pressures and unsafe conditions on impacts faced by a community following a disaster. A disaster is the intersection of two opposing forces: 1) the processes and conditions that generate vulnerability of a system and 2) the natural hazard event (or a slowly unfolding natural or human-induced process) leading to physical exposure to a hazard (Quarantelli, 2005; Westerhoff and Smit, 2009). Unlike the impact-based approach, the PAR model recognises that impacts are a joint result of the interaction of climate and society whereby the same climatic conditions will yield different impacts under varying sets of social conditions (Kates, 1985). Understanding characteristics such as the infrastructural, economic, societal and institutional state of a system is key when considering the social processes and conditions that generate vulnerability (Singh et al., 2014). Such characteristics are referred to as *determinants of adaptation* by Smit et al. (2001) in IPCC's Third Assessment Report (TAR). The PAR model has advanced our understanding of the endogenous factors that create risk such as the limited access to power, structures and institutions, the geographical location of the community, income levels, and demographic pressures labelled as 'root causes', 'dynamic pressures' and 'unsafe conditions' in the model (Figure 2.3).

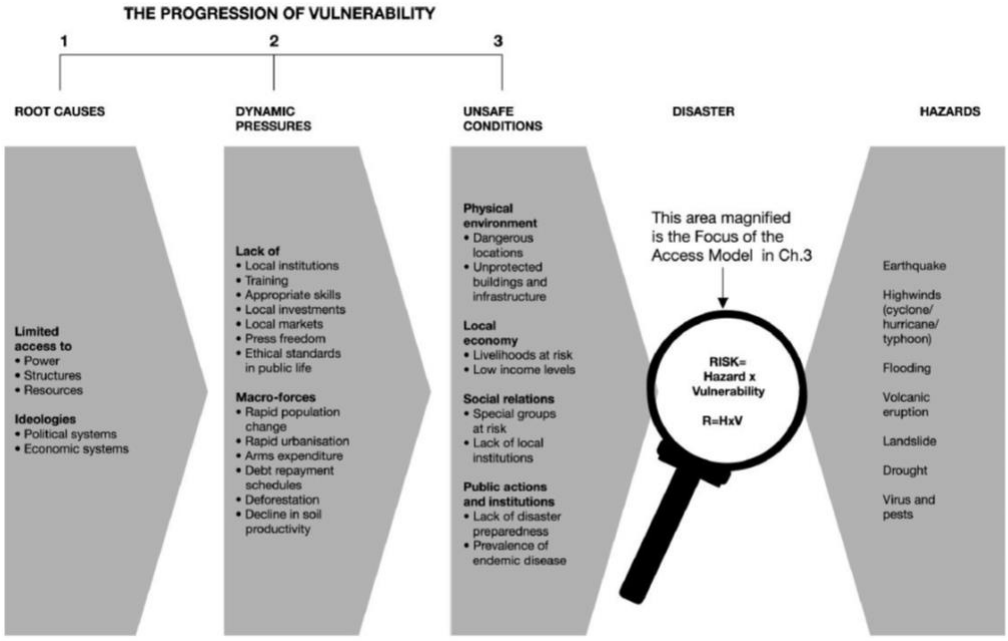

Figure 2.3 *Pressure and Release model: The Progression of Vulnerability*
Source: Wisner et al., 2003

2.2.2.3 Sustainable Livelihoods Approach (SLA)

The Sustainable Livelihoods Approach (SLA) is an analytical tool which considers key resource groups known as livelihood assets or commodity bundles that a community or system possesses and which facilitate responses and adaptations to environmental and climatic changes (Bebbington, 1999; Smit et al., 2001; Reed et al., 2013). Rather than reinforcing a 'victim mentality' among vulnerable communities as do traditional approaches (impact-based approach), the SLA starts by identifying assets and works to build upon these assets to increase resilience (Gutierrez-Montes et al., 2009).

The five 'capitals' can be classified as *human* (intangible), e.g. social networks, skills, knowledge, or *material* (tangible), e.g. shelter, water, land (Adger and Kelly, 1999; Krantz, 2001). These five determinants influence (by hindering or enhancing) the ability of a system to adapt to ongoing change and include social, human, natural, physical and financial capitals (Table 2.3). The nature of the capitals differs in that they can be: (a) consumed (used and depleted), (b) stored and preserved (to be used by no one) and/or (c) invested to create more resources for the system (Emery and Flora, 2006; Flora et al., 2004). Complementing the five capitals of the SLA, the Community Capitals Framework (CCF) incorporates cultural and political capitals into the tool (Bebbington, 1999; Flora et al., 2004; Emery and Flora, 2006; McLean, 2015).

Table 2.3 *Livelihood assets constructing the SLA and CCF*

Framework		*Capital type*	*Definition*	
Sustainable Livelihoods Approach	*Community Capitals Framework*	**Social capital** (human)	• Networks and connectedness • Memberships of formalised groups (rules, norms and sanctions) • Relationships of trust, reciprocity and exchanges (informal safety nets)	
		Human capital (human)	• Skills • Knowledge	• Labour • Health
		Natural capital (material)	• Land • Forests • Marine/wildlife resources • Water • Air quality	• Erosion protection • Waste assimilation • Storm protection • Degree and rate of biodiversity change
		Financial capital (material)	• Available stocks (savings) • Regular inflows of money (income)	
		Physical/built capital (material)	• Affordable transport • Secure shelter and buildings • Adequate water supply and sanitation • Clean, affordable energy • Access to information (communications)	
		Cultural capital (human)	• Local worldviews • Dictates what voices are heard and listened to	
		Political capital (human)	• Access to power and institutions • Ability for people to have individual power within a system	

The systematic identification of factors, or lack thereof, that determine resilience of a system identifies an entry point whereby increasing access to a certain livelihood asset would increase resilience and decrease vulnerability of a system to harm despite undergoing change. Systematic measurement of livelihood assets can be represented on a spider diagram to visually present where a system requires promotion or protection of a certain livelihood asset to increase the capacity of the system to adapt to ongoing change, e.g. Figure 2.4 (Ganase and Teelucksingh, 2012; Saldajeno et al., 2012; Panthi et al., 2016). The expansion of the central area represents the development of adaptive capacity. The SLA complements the PAR model which includes a focus on physical, social, human, financial and political capitals as endogenous factors that create risk. Rather than solely identifying these factors, the SLA intends to provide the basis for action by determining livelihood assets of a community to enhance which will increase resilience and, in turn, reduce vulnerability.

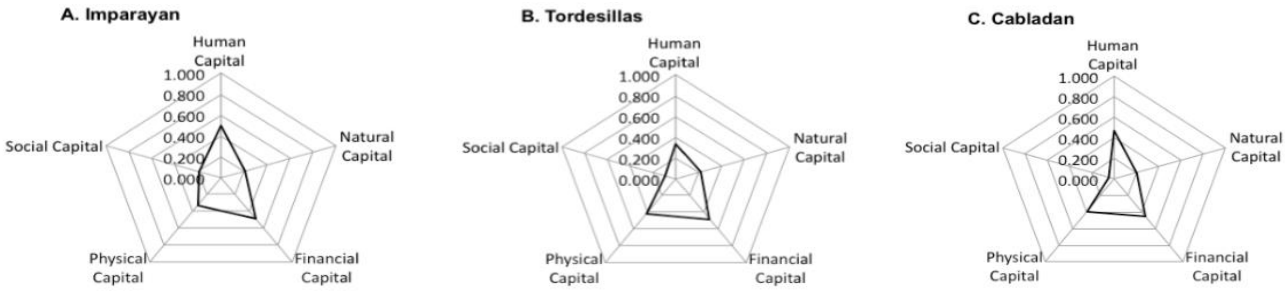

Figure 2.4 *Vulnerability spider diagrams*
Source: Saldajeno et al., 2012

2.2.2.4 The vulnerability approach

Smit and Wandel (2006) built on Smit and Pilifosova's model, expanding the concept of exposure and emphasising the importance to recognise the level of sensitivity in which a system has to particular stimuli. This expansion along with the temporal separation of exposure-sensitivities and adaptive strategies and capacities formed the basis of the vulnerability approach which has been a popular conceptual model used in recent empirical community-based vulnerability assessments (Sutherland et al., 2005; Fazey et al., 2010; Pearce et al., 2010; McCubbin et al., 2015). The vulnerability approach (Figure 2.5) builds upon the impact-based approach, PAR model and SLA to examine vulnerability at highly localised scales under a set of unique conditions taking into consideration of all available (or lacking) livelihood assets. The functional relationship between exposure-sensitivities and adaptive capacity is not specified due to variation dependant on location, context, sector and time.

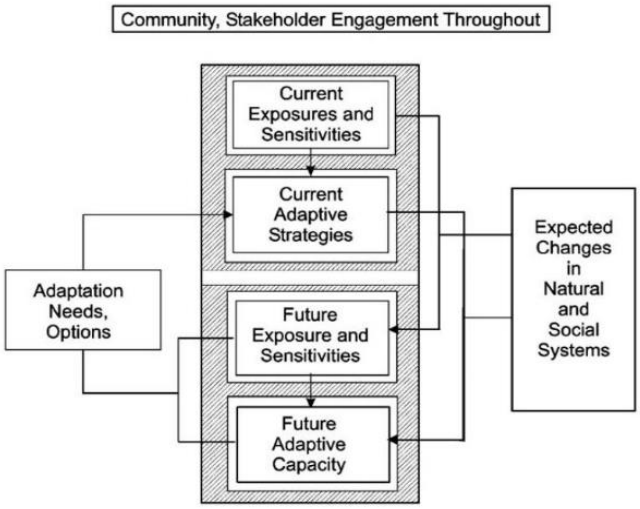

Figure 2.5 *Ford and Smit's conceptual framework for the vulnerability approach*
Source: Ford and Smit 2004

Taking a bottom-up approach, this model operates with the researcher not presuming to know the exposure-sensitivities existing in the community so that these are identified by members of the community itself (Smit and Wandel, 2006). This two-step analytical framework is used to structure empirical assessments of what is known and not known about climate change vulnerability. This framework is applied to a place-specific case study in two stages to 1) assess current vulnerability by documenting current exposure-sensitivities and current adaptive capacities and 2) assess future vulnerability by estimating directional changes in exposure and predicting future adaptive capacity based on past behaviour. Both stages utilise participatory observation methodologies with active involvement of multiple stakeholders and decision-makers as well as integrating knowledge from multiple sources (Smit and Wandel, 2006). As a participatory vulnerability assessment, this model allows the recognition of multiple stressors that generate vulnerability beyond climatic changes. The

purpose of this methodology is to attain information on the nature of vulnerability within a location-based case study and to establish ways in which the adaptive capacity can be increased and the exposure-sensitivities reduced.

2.3 Human Dimensions of Climate Change in the Pacific Islands region

Much of the research on the human dimensions of climate change in the Pacific Islands region has started by instrumentally measuring biophysical impacts of climate change and then assuming potential consequences for human communities, often with minimal input from the people who are the focus of the research (Woodward et al., 1998, Barnett and Campbell, 2010; Nunn, 2013). This research focuses on measuring biophysical changes (sea-level rise, climate variation, shoreline change) at broad scales based on historical information or climate models and scenarios (e.g. (Arnell, 2004; Ebi et al., 2006; Nunn, 2009; Barnett and O'Neill, 2011; Nunn, 2013; Hernández-Delgado, 2015; McLean and Kench, 2015; Albert et al., 2016). These impact-based assessments rarely include the knowledge and experiences of local people or endogenous factors, which influence how climate risks are experienced and responded to such as land tenure, kinships, culture and livelihoods (Barnett and Campbell, 2010). As such, proposed adaptation strategies often prove to be disconnected with society and where implemented, have proven to be ineffective (Barnett and Campbell, 2010).

Other research has started with the human system of interest, to understand what climate conditions are relevant and important to people and what adaptations are realistic and desirable. This research often includes local knowledge and observations of climate change with scientific measurements to generate a broader understanding of change. This research has been conducted in place-specific empirical case studies and has uncovered some common cross-cutting themes including, the sensitivity of food, land, and water resources to climate change (McCubbin et al., 2015), migration and 'climate refugees' (Mortreux and Barnett, 2009; Farbotko and Lazrus, 2012), disaster risk reduction and management (Pelling, 2010; Glavovic and Smith, 2014), adaptability to climate variability and extreme weather events (Sutherland et al., 2005), health and well-being, (Barnett and Campbell, 2010), traditional knowledge transmission and application (Nakashima et al., 2012), and the influence of traditional governance systems and human agency to adapt (Glavovic and Smith, 2014). The following sections review HDCC scholarship in the Pacific Islands region following the structure of vulnerability described by Smit and Wandel (2006) and outlined here in section 2.2.

2.3.1 Current and future exposure-sensitivities

Current and future exposure-sensitivity refers to the susceptibility of people and communities to changing conditions (climatic and non-climatic) now and in the future (Smit and Wandel, 2006; Pearce et al., 2010). It is dependent on both the characteristics of climate-related stimuli (frequency, duration, magnitude, speed of onset) and community characteristics (location, livelihoods, economy,

infrastructure) which give the ability of that system to adjust and adapt to reduce harm from the said impacts (Smit and Wandel, 2006; Miller et al., 2010).

Small-scale fisheries and agriculture are the main sources of food and income in traditional Pacific Island communities; activities that are sensitive to changes in climate. Inshore marine environments, particularly reef ecosystems, are unique for their abundance and diversity of life, which coastal communities depend on for subsistence. Minute biophysical changes (coral cover, pH, temperature, salinity) in these environments can have drastic repercussions for the populations who are dependent on them (Seidel and Lal, 2010). Degradation of marine ecosystems and agricultural land contributes to food scarcity concerns as well as reducing the ability of Pacific Islanders to partake in livelihood activities such as selling of produce at local markets for income or using produce in traditional bartering systems (Hauriasi and Davey, 2009). Degradation of nearshore marine ecosystems across the Pacific Islands region has been documented due to a range of climatic and non-climatic stresses over time including heat stress (Normille, 2016), over-exploitation by means of overfishing or coral removal (Wabnitz et al., 2003; Why and Tuwai, 2005), unsustainable fishing practices and mangrove destruction (Gilman et al., 2006), over-population and high levels of development in the coastal zone (Campbell, 2014), and changing inland land use and attributed increased nutrient and sediment loads (Moberg and Folke, 1999). Agriculture is perhaps the most climate-sensitive sector, with output directly affected by even slight climatic variability and the heightened frequency and intensity of extreme climate events already being experienced (Turral et al., 2011). Changing climatic conditions, altered rainfall regimes and extreme temperatures have limited agricultural productivity resulting in food scarcity in some Pacific communities, E.g. Funafuti, Tuvalu (McCubbin et al., 2015). Recent IPCC Assessment Reports (4AR and AR5) maintain that increasing temperatures, sea-level rise, inundation, seawater intrusion into freshwater lenses, soil salinisation, decline in water supply and more frequent and intense extreme weather events are very likely to adversely impact coastal subsistence agriculture of small islands (Mimura et al., 2007; IPCC, 2014b). Degradation of agricultural systems and marine ecosystems has been observed in numerous cases among Pacific Island communities and this is expected to continue as variable weather patterns coupled with changing sociocultural conditions translate to affect people (Wheeler and von Braun, 2013; Campbell, 2014; McIver et al., 2015).

Pacific Island countries are sensitive to the health impacts of a changing climate due to their exposure to observed and projected SLR, ocean acidification, increasing land and sea temperatures and increased severity of extreme weather events, and the limited capacity of the health care system to manage and adapt to such risks (Barnett and Campbell, 2010; McIver et al., 2015). Climate change affects human health both directly and indirectly (McMichael et al., 2003). For example, more frequent and severe extreme weather events, loss of agricultural productivity, marine ecosystem service decline, freshwater scarcity and rising temperatures directly threaten the health and well-being of Pacific Island populations by causing heat-related illness, water-related stress (including hygiene

and disease), food insecurity and psychosocial concerns (Nurse et al., 2014; Wong et al., 2014; McIver et al., 2015). Climate change acting via less direct mechanisms is likely to affect the transmission of many infectious diseases (especially water, food and vector-borne diseases) and regional food productivity (McMichael et al., 2003; Epstein, 2005). Health services in most Pacific Island countries are under-equipped and already struggling to cope with existing health concerns and the increased health burden of climate change will inevitably put strain on the already stressed health system (McIver et al., 2016).

Sea-level rise is expected to exacerbate inundation, storm surges, erosion and other coastal hazards that will threaten vital infrastructure, assets, settlements and facilities that support the livelihood of Pacific Island communities (Wong et al., 2014). Exacerbating this issue is the existence of vital infrastructure predominating in coastal zones with high proportions of populations living extremely close to coastlines (Asian Development Bank and International Food Policy Research Institute, 2009). Most international airports, roads and capital cities in the Pacific Islands region are located along the coast, or on small coral islands (Mimura et al., 2007). There have been numerous occurrences of structural and property damage of houses, infrastructure and agricultural land in Pacific Island communities caused by both gradual environmental change that push systems to a tipping point (sea level rise, increasing temperatures) as well as episodic natural disasters (earthquakes, landslides, floods, tsunamis) (Sutherland et al., 2005; Spennemann, 2006; Walsh et al., 2012; Ford, 2012a; Hoeke et al., 2013). Damage most commonly is a result of two forces: 1) excessive waters (rising seas, heavy rain, floodwaters, storm surges) eroding and inundating land and property, and 2) excessive winds jeopardising structural integrity of houses and other buildings, and destroying food crops and trees (Shelter Cluster Fiji, 2016). Remote and rural Pacific Island communities often are forced to manage temporarily disconnected from vital services if access roads are inaccessible due to flooding or inundation. Residents of East Kwaio, Malaita and Nuatambu village, Solomon Islands, for example, have endured limited access to schools, markets and health centres due to intruding high tides and constant inundation of access paths during high tides (Albert et al., 2016; Asugeni et al., 2016). Fresh water resources have also been affected though changing precipitation regimes and temperature norms resulting in saline intrusion into freshwater lenses, salinisation of agricultural land and depletion of freshwater resources (Mortreux and Barnett, 2009; Warrick et al., 2013; Nurse et al., 2014; McCubbin et al., 2015). Water security and safety were prioritised as health risks in all 13 study locations within a regional climate change and health vulnerability assessment led by the World Health Organisation (McIver et al., 2015). Hunter et al. (2010) identify six factors that determine whether a water supply can effectively maintain good health; the quality of the water, the quantity of available water, the accessibility to water (distance, terrain), the reliability of the water supply; the cost of water to the user, and the ease of management for the user. Where one of these factors is undesirable, the potential of ill health increases. Communities in remote areas are commonly more dependent on unprotected and untreated water

sources such as rivers, stream and shallow, open wells which are prone to contamination, increasing the risk of ill health (Singh et al., 2001).

Indigenous peoples' culture is rooted in strong relationships with the natural environment (Willox et al., 2013). Changing the ability of populations to interact with the natural environment can affect participation in traditional livelihood activities, with implications for interpersonal and environmental relationships, stewardship and oral history (Ford, 2012b). Participation in traditional land-based activities is also effected by ongoing socio-economic changes (Willox et al., 2013). The identity, livelihoods, culture and mental wellness of Indigenous populations of the Pacific Islands region is traditionally very closely tied to land and sea environments (Hau'ofa, 1994; Hviding, 2006). The close connection people have with the land and sea has been passed on between generations for millennia where comprehensive and holistic knowledge of the environment facilitates the thriving of millions of people across the Pacific Islands region. The Fijian concept of *vanua* captures the close connection between physical space and cultural existence. Nabobo-Baba (2006) and Ratuva (2002) describe *vanua* as the incorporation of three inter-related realms: the territorial sphere including soil or land; social kinship; and cosmological dimensions. *Vanua* in research refers to the universal whole, which is inclusive of a chief or related chiefs, their people and their relationships, their land, spiritualities, knowledge systems, cultures and values (Farrelly and Nabobo-Baba, 2012). Furthermore, the *vanua* is pivotal to Fijian people's identity and is the heart of their existence, central to the essence of being Fijian (Farrelly and Nabobo-Baba, 2012). Changing societal conditions such as engagement in western education systems and wage employment can reduce the opportunity to engage in land-based activities, lessening the knowledge of younger generations of weather patterns and ocean conditions, ultimately limiting their ability acquire and eventually transmit this knowledge to emerging generations. A loss of customary rights has been observed through privatisation of land and changes to 'modern' tenure systems. Generally speaking, socio-political institutions that govern traditional life in the Pacific Islands region are traditional chiefly systems, government institutes and democratically elected role of the village headman and Christian churches (Henrich and Henrich, 2004). Some researchers have claimed traditional governance systems have acted as a barrier to effective adaptation efforts (Nunn et al., 2014) while others maintain these systems, along with the utilisation of traditional ecological knowledge (TEK), effectively allow populations to adapt to changing conditions and opportunistically harbour conditions influenced by the effects of climate change (e.g. warmer temperatures, seasonal shift) (Barnett, 2001; Leonard et al., 2013).

2.3.2 Current adaptive strategies and future adaptive capacity

It is sometimes assumed that all Pacific Island communities experience and can respond to climate change uniformly; however, climate change impacts are highly localised due to local variations in social history, culture, land-use practices and economy (Duerden, 2004). The vast geographic and cultural differences among Pacific Island countries result in an incredible diversity of

capacities to adapt to climate change. Adaptive capacity is influenced by several factors including, but not limited to, geography, access to financial, social and capital resources, and environmental knowledge and land skills (Yohe and Tol, 2002). Adaptive strategies and capacities can be proactive, concurrent, reactive, and stretched across temporal and spatial scales (Smit et al., 2000; Pearce et al., 2010; Sovacool, 2011). Where it is possible to employ short-term adaptive strategies, it is likely these will evolve to become a more long-term solution, increasing adaptive capacity of the system to respond to future conditions.

Current adaptive strategies employed to cope with food scarcity onset by declining agricultural productivity and marine resource harvests among remote populations in the Pacific Islands region include food sharing through social networks, crop diversification, implementation of innovative farming techniques and engaging in wage employment either locally or faraway (Reenberg et al., 2008; Mortreux and Barnett, 2009; McCubbin et al., 2015). Bell et al. (2013) identify opportunities that may exist for Pacific Island communities in the light of changing conditions such as expanding potential to produce cocoa or farm freshwater fish species such as tilapia in rivers or ponds in a warming climate for supplementary income. These strategies, however, are not always possible for geographically isolated communities. For instance, geographical smallness reduces the ability to diversify crops and limits the extent and reliability of social networks, while remoteness creates logistical difficulties by restricting movement of imported/exported goods as well as human movement.

Pacific Island communities have applied adaptive strategies including storing water for use in times of drought and flooding (to avoid contamination), constructing seawalls to protect property from imposing waters, financial remittances, retreating inland to higher ground or increasing the resilience of houses by strengthening the construction of existing houses (Sutherland et al., 2005). Increasing storage and enforcing sustainable use of freshwater resources are key strategies employed by Pacific Island communities to ensure the finite resource is most efficiently consumed (Cawaki, 2012). Installation and maintenance of rainwater tanks has been prioritised in some communities while others have imposed water restrictions upon themselves to reduce wastage and ensure sufficient water supply indefinitely (Silaitoga, 2015; Pearce et al., 2018).

Ultimately, permanent relocation becomes necessary when land becomes irreversibly unproductive and food crops can no longer be cultivated, where there is no alternative land for agricultural purposes and where sharing or importing is infeasible due to costs or logistics. While permanent relocation has been considered an adaptive strategy by some (Birk, 2012; King et al., 2014), it is concurrently considered as maladaptation by others; understood to relocate vulnerability rather than reduce it, putting excessive pressure on already depleting resources, overwhelming infrastructure and potentially creating cultural and ethical tensions (Coelho, 2013; Gromilova, 2014; Magnan, 2014).

Economic and institutional support in the form of government funding and programs has increased the capacity of vulnerable populations to cope with and adapt to changing conditions while increasing the capacity for a community to adapt to future change. While wage employment and education are highly valued for ongoing contributions to community and national development, these cultural and educational changes reduce the effectiveness of traditional adaptive strategies such as sharing networks, flexible farming/fishing practices and weather and season prediction. Limited time spent in environments reduces the ability to acquire traditional ecological knowledge and skills, further reducing the ability to respond and adapt to increasingly unpredictable environments. Integration of cultural traditions in formal schooling processes ensures the transmission of values, skills and knowledge, providing younger generations access to these vital skills (McCarter and Gavin, 2011; Nabobo and Teasdale, 1994). Furthermore, 'mainstreaming' climate change adaptation initiatives into existing institutions and decision-making processes makes adaptation efforts more effective (Huq et al., 2003; Klein et al., 2007; Pearce et al., 2010; Berrang-Ford et al., 2011). Mainstreaming adaptation efforts with other programs such as disaster risk reduction and management and resource management initiatives increases financial, health, educational and cultural capacity in the community which inadvertently increases the adaptive capacity of the community to deal with current and future climatic risks (Huq et al., 2003; Klein et al., 2007; Pearce et al., 2010). Mobilising social memory to link past experiences and associated successful adaptations embedded in a deep set of cultural values can assist in present and future policy development while drawing upon novelty, innovation and experimentation to address unfamiliar conditions (Folke et al., 2005).

2.4 Traditional Ecological Knowledge and Adaptation

There is widespread interest in, and legislative and policy support for, the inclusion of traditional knowledge within environmental impact assessments and climate change adaptation planning (e.g. Ford, 2012b; Ford et al., 2012; Nakashima et al., 2012; Maru et al., 2014). The term 'traditional knowledge' is sometimes referred to as, and can be used interchangeably with, Indigenous knowledge and is broadly defined as a cumulative body of knowledge, practice, and values acquired through experience and observations on the land or from spiritual teachings and handed down between generations (Pearce et al., 2015a). Traditional ecological knowledge (TEK) is a subset of this knowledge with a specific focus on the knowledge of the environment, commonly defined as a holistic body of knowledge and beliefs transmitted through oral tradition and first-hand observation of cultural and biophysical elements which is both cumulative and dynamic, building upon the experience of earlier generations and adapting to the new changes of the present (Stevenson, 1996; Wenzel, 1999; Usher, 2000). Some scholars have described the role that TEK plays in adaptation to environmental changes (Ford et al., 2012; Ford, 2012b; Maru et al., 2014; Pearce et al., 2015a). TEK is known to provide holders the flexibility necessary to cope with and adapt to climate variability along with the interaction with non-climatic factors including population growth, urbanisation,

cultural and social shifts and changing economic demands (Berkes and Jolly, 2001; Pearce et al., 2015a). Care must be taken when interpreting the term 'traditional' as in this context as it could be used interchangeably with 'aboriginal (although not restricted by aboriginal genetics or heritage) and is current and continually evolving rather than remaining a static or non-adaptive body of knowledge (Usher, 2000).

Indigenous people worldwide have long and multi-generational histories of interaction with their environments that include coping with environmental uncertainty, variability and change (Nakashima et al., 2012). Pacific Islanders explored and inhabited islands scattered within vast expanses of the Pacific Ocean using traditional navigation and wayfinding techniques (Lewis, 1971), and more contemporarily sustainably managing finite natural resources (Lauer and Aswani, 2010). The success of many communities in the Pacific Islands region is rooted in knowledge of food production including traditional weather forecasting, land preparation, cropping and soil and water management, and food procurement (Lefale, 2009; Lebel, 2012). The ability of people to draw on TEK to deal with changing conditions depends on the generation and transmission of TEK among generations (Pearce et al., 2015a).

In the context of climate change, TEK can help build an understanding of climate impacts on ecological processes and phenomena across spatial and temporal scales for different organisms, habitats, and various ecosystems (Nabhan, 2010). Hence, the applicability of TEK associated with socio-economic and adaptive human responses to environmental change can make an important contribution into understanding impacts from climate change and strategies for adaptation on local bases. This is highly attributable to the ownership of TEK and highlights the importance of continual transmission of this knowledge to emerging generations for use in the face of future climate change (Pearce et al., 2010; Nakashima et al., 2012). The Fourth Assessment Report (AR4) of the IPCC acknowledged Indigenous knowledge or TEK as 'an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change' (Anisimov et al., 2007, p. 673-674). Now, it is vital that this knowledge is operationalised and used to guide policy and adaptation efforts because although the value of TEK has been globally recognised, the utilisation of it is still piecemeal and largely unused in adaptation efforts (IPCC, 2014a).

Traditional knowledge can be documented in various mediums (academic journals, interactive multi-media CD-ROMs, documentary films, traditional seasonal calendars) which are recognised to benefit both local people and researchers (Riedlinger, 1999; Mondragón, 2004; Nakashima and Nilsson, 2006; Prober et al., 2011; SPREP, 2016). Where used effectively, TEK is highly valued for the immense contribution it can have to holistic understandings of environmental impacts of projected climate changes, proposed projects or adaptation plans (Stevenson, 1996). In an Arctic context, but applicable to other locales, benefit of documenting TEK include 1) helping local people preserve traditional knowledge through this documentation, 2) providing local knowledge and information to decision-makers at various levels for climate change strategies and policies, and 3)

developing effective tools to enhance communication between local people and researchers (Fox, 2002). TEK should provide an essential communication bridge between the holders of the knowledge and the decision-makers who may exist at any level of governance – national, regional/district, local/village or household. Where TEK is sought to contribute to large-scale policy or adaptation development it is necessary to be documented in scientific or peer-reviewed literature as documentation in grey literature remains largely outside the scope of IPCC assessments (Nakashima et al., 2012).

2.5 Knowledge Gaps and Research Opportunities

Several knowledge gaps in our understanding of climate change impacts, vulnerability and adaptation (IVA) in the Pacific Islands region are evident in the reviewed scholarship. ***First,*** climate change IVA is highly localised with impacts being felt uniquely in differing geographical locations. However, most research has been conducted at broad scales and understanding of human adaptation is based on assumptions rather than empirical evidence. ***Second,*** most research in the Pacific Islands region region focuses on measuring biophysical changes in the environment including, sea level, sea and surface temperatures, weather and seasonal patterns, and extreme weather events including cyclones, floods and droughts (Farbotko and Lazrus, 2012; Burkett et al., 2014; Nurse et al., 2014). There is a need for research that examines how these changes translate to affect human lives and livelihoods and adaptation options (Barnett and Campbell, 2010; Castree, 2016). There is a need to employ bottom-up approaches such as the vulnerability approach to identify vulnerabilities at local scales rather than assuming impacts and adaptations based on regional level assessments. ***Third,*** some community-based vulnerability assessments have been conducted with people living in urban areas in the Pacific Islands region but few have been conducted with people living in geographically remote locations (Sutherland et al., 2005; Mortreux and Barnett, 2009; McCubbin et al., 2015). Some research has been conducted in rural communities of remote islands including on Druadrua Island, Fiji, (Johnston, 2014; Dumaru, 2010), South Tarawa, North Tabiteuea and Butaritari Islands, Kiribati, (Kuruppu and Liverman, 2011), and the Reef Islands, Solomon Islands, (Birk, 2014). In their own way and within varying contexts, each of these studies highlights the unique challenges and disadvantages that are sometimes faced by rural communities. No adaptation research conducted with people living in the interior of Fiji appears in the peer-reviewed literature. This research sought to address these knowledge gaps by employing a bottom up approach to identify and characterise how climatic and non-climatic risks and change are experienced and responded to in a geographically remote location in Fiji's interior.

Chapter 3: Case Study

3.1 Nawairuku village

Fiji lies in the Southwest Pacific Ocean between 177°E-178°W and 16°S-20°S. The country comprises 322 islands with a total landmass of 18,333km^2 and population of 884,887 (Fiji Bureau of Statistics, 2018; Australia Bureau of Meteorology and CSIRO, 2011b). The two largest islands, Viti Levu and Vanua Levu make up 87% of Fiji's total land mass and are mountainous of volcanic origin. Other islands are smaller volcanic islands, low-lying atolls and elevated reefs. Ra province is positioned in the north-east quadrant of Viti Levu and is known as one of Fiji's "salad bowls" because of the high production of root crops and *yaqona* (kava plant). Ra province covers an area of 1,340km^2 and has two major towns, Rakiraki and Vaileka, and 89 villages. This empirical study was undertaken in Nawairuku village, because it is an interior village and also because a local contact in Fiji facilitated acceptance in the village.

Nawairuku village is located an elevation of 51 metres above sea level (17°38'15.52"S, 178°12'51.66"E). The village is situated in a riverine valley surrounded by steep forested and cultivated hills. Nawairuku has a population of approximately 320 (100% *iTaukei*) residing in approximately 60 households (personal observation 2017). The village is situated within mountainous terrain typical of the Fijian highlands surrounded by dense tropical forests and steep slopes. A tributary of the Lawaki River flows through the village, which is a tributary of the larger Wainibuka and Rewa Rivers (Figure 3.1). All families rely on subsistence farming and livestock for subsistence and income. Commonly harvested foods include root crops (cassava, *dalo*, sweet potato, yam, *yaqona*), fruits (coconut, banana, watermelon, plantain, breadfruit, mandarin, papaya), vegetables (tomato, cucumber, eggplant, pumpkin, *bele*, taro leaves, chillies and Chinese cabbage). Cassava, *dalo* and banana are the main cash crops providing most of received agricultural income. Bullocks are used to plough farmland and horses are used for localised transport. Some pigs are raised for consumption, ceremonial use and gift-giving. There are two access roads to the village: the most direct is via Kings Road with a bridge crossing the Rewa River and the second is the alternative inland route used when there is damage to the bridge.

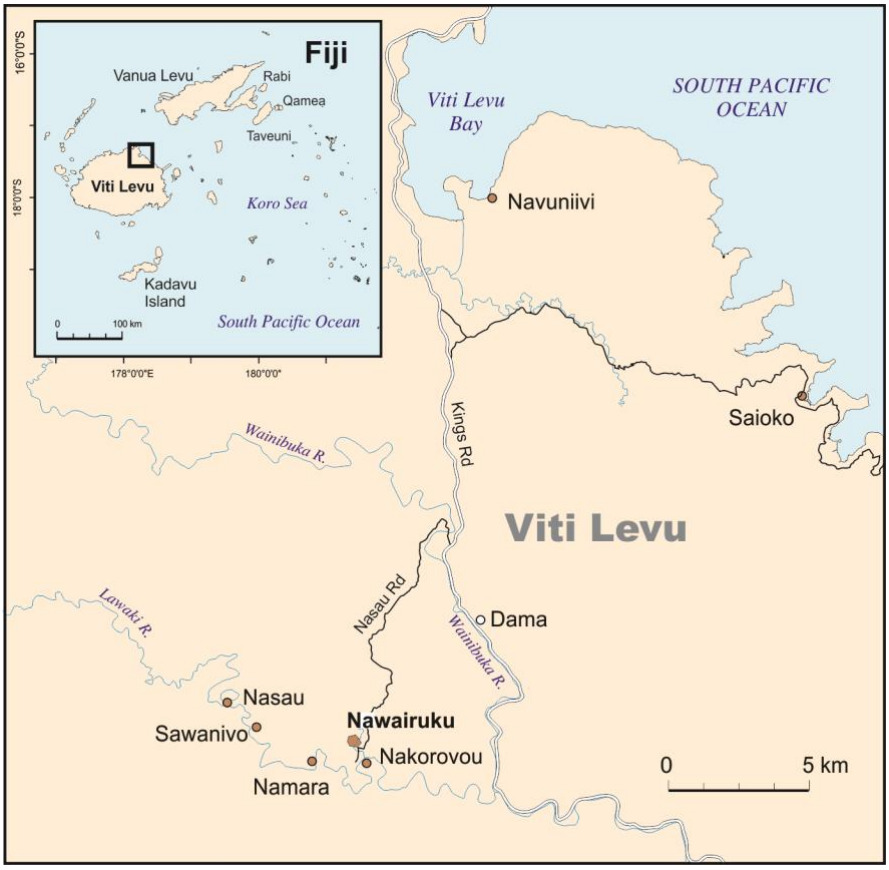

Figure 3.1 *Location of Nawairuku village in Ra Province, Viti Levu, Fiji*

Approximately 87% of land in Fiji is Native Land belonging to Indigenous land-owning units, *yasanas* or *mataqalis* (Native Land Trust Board, 2018). The land directly surrounding the village is traditionally owned by the paramount chief of the *yasana* (Lawaki), who does not reside in the village. Outside ownership of the land limits how villagers can use the land. Village-owned land is located 'in the bush' approximately five kilometres away. This is the where farmland is being developed and expanded to increase production for commercial use. The main source of water is a small concrete dam approximately 2.8 km away and water is transported to the village via pipes into a communal water tank (20,000L capacity). The water is then distributed through the village grid to individual household taps. This dam serves the village as well as Liwativale Primary School. In times of water stress (i.e. dry season, after extreme weather events) the dam struggles to provide a sufficient volume of water and the communal tank is regularly disconnected from the distribution grid to allow the tank to refill.

People have various ways to sell crops. Several middlemen service the village by regularly collecting produce in trucks and continuing to sell these to market vendors. Although this is the most convenient means of selling crops, villagers receive a lower price for their goods than if they were to take it to market themselves. Some people travel in carriers to the market with their produce and proceed to work at a stall at Rakiraki or Lautoka markets, selling their goods at a more profitable price. While this option yields a higher selling price, there are transportation costs that lower overall

profit. Costs to access the Rakiraki market include: FJD$20 return carrier fare for the seller, an additional FJD$5 for each sack of cargo, and a full days' work. To access Lautoka market costs include: FJD$100 return fare for the seller (including cargo), and between two and three days' work. Some people give their cargo to other villagers who will be going to the market. Both parties negotiate a for the profit of the crops to be handed back to the owner, minus a small charge for delivery (usually $10 which is kept by the travelling party). This option is popular for people who have no desire to go to town (e.g. if they are minding young children at home, they are busy working on the farm or elsewhere, or are elderly and unable to travel, etc.)

The political positioning of Nawairuku is reflective of the traditional Fijian stratification. Fiji is divided into 14 administrative units called provinces, or *yasanas*. Each *yasana* is governed by a Provincial Council that the acting administration body between villages and upper government. Each province (*yasana*) is divided into sub-districts (*tikinas*) comprising a number of villages (*koros*). A Fijian village (*koro*) is typically comprised of clans (*mataqalis*) that, in turn, are comprised by smaller family groups (*tokatokas*). Each *mataqali* has a leader, generally the eldest person in the group, and strives to ensure all people know their customary roles and responsibilities to contribute to the makeup of the village. Each village is led by a locally elected village headman (*turaga-ni-koro*) and a hereditary chief. Nawairuku is one of four villages comprising the tikina Lawaki (Nakorovou, Namara, Sawanivo are the additional three villages). The village, like other villages in Fiji, has a number of village-scaled committees who discuss and act on a number of issues (water, health, school, women's, development, youth committees).

As described in the Chapters 5 and 6, Fijians have a long history of coping with and adapting to environmental changes. The speed and magnitude of recent climatic changes, however, are new and are being experienced together with other social and environmental changes. In particular, people are increasingly dependent on crops for commercial reasons and associated cash incomes. It is also noteworthy that the location of the village has changed over time, which has changed how it is exposed to natural disasters such as cyclones and floods. Previously the village was located further inland in the hills where safety was sought during wartimes. In the late 1800s, the village was relocated to a lower elevation at a location close to the current village site. The village experienced a severe flood in the 1980s causing damage to houses and crops, and prompting a second relocation to the current village site on the opposite side of the river.

Figure 3.2 *Nawairuku village from above. Photo: Roger Kitson*

Chapter 4: Methods

4.1 Research Approach

The research was undertaken with community members in Nawairuku village using a bottom-up approach to study climate change impacts, vulnerability and adaptation described by Ford and Smit (2004) and Smit and Wandel (2006) and consistent with Turner et al. (2003) and Fazey et al. (2010) (Figure 2.5). The approach is distinct from other climate change assessments in that it does not pre-determine climate change to be of importance but instead starts by having community members identify conditions, societal and environmental, that are relevant and important to them, beyond those readily captured in climate models (e.g. temperature, precipitation). Here, climatic exposures are considered in the context of multiple climatic and non-climatic stressors, which influence how people experience and respond to risk.

The vulnerability approach consists of two stages of assessment (Pearce et al., 2010, p.160). The first stage assesses "current vulnerability".

- Identify the conditions or risks (climatic and non-climatic) that are relevant to the people in the community (referred to as exposure-sensitivities).
- Identify and assess the strategies employed in the community to cope with and adapt to exposure-sensitivities.

The second stage assesses "future vulnerability" by incorporating future climate probabilities and future social probabilities to estimate directional changes in exposure-sensitivities and associated adaptive capacities.

- Estimate future risks or exposure-sensitivities based on likely changes in conditions that were identified as being of importance to community livelihoods.
- Assess the capacity of the community to adapt to future conditions based on current adaptive capacity and future demographic and socio-economic projections.

Information on current and future vulnerabilities was obtained primarily from data collected through semi-structured interviews with community members, secondary sources of information and participant observation. The inclusion of community members in vulnerability assessments has proven to deliver in-depth accounts and real-life areas of concern from a grassroots approach (Pearce et al., 2018; McCubbin et al., 2015)

There is a global movement to decolonise research methodologies when carrying out research with Indigenous peoples (Smith, 1999). This has resulted in the development of Indigenous research methodologies, protocols and practices, including the *Vanua* Research Framework for Fiji (Appendix 1) (Nabobo-Baba 2006; 2008). The research was guided by the *Vanua* Research Framework and considerations for conducting research with communities described by Pearce et al. (2009), Movono and Dahles (2017), Anderson (2015) and Movono et al. (2018). The researchers visited Nawairuku in April 2017 together with representatives from the village to discuss the proposal with community

members and elicit feedback on the research aim, study design, and methods. Upon confirming local support for the research, the researchers returned to Australia and prepared applications for a research license and ethics approval. Approval for the research was granted by the Fijian Department of Immigration (#I7497899), which oversees research in Fiji and study protocols were approved by the Human Research Ethics Boards at the University of the Sunshine Coast (A/15/751) and University of the South Pacific (Appendix 4 and 5). The researchers returned to Nawairuku in June 2017. Their first action was to visit the Office of the Commissioner Western in Lautoka, together with a village leader, to discuss the research and obtain support for it. A visit was also paid to the Ra Provincial Council office to meet with staff and share research ideas.

4.2 Data collection

Data were collected over a 10-week period between June and August 2017 by Currenti and two research partners, Teresia Salabogi and Luke Vuli. Verbal and written consent was obtained from each respondent (Appendix 6). Multiple data-collection techniques were used, including semi-structured interviews using open-ended questions (n=30), focus groups (n=2), freelisting exercises (n=30), participant observation, and analysis of secondary sources (government documents, climate data, published and unpublished research). Key informant and snowball sampling techniques were used to identify interview participants (Patton, 2014). This started with key informants (village head person, local research assistant) who then assisted in identifying a cross-section of the adult population in Nawairuku (Table 4.1). In particular, long-term residents of the community or who are particularly knowledgeable about history of change were identified. Sample size was determined by reaching a point of saturation. All 30 participants were *iTaukei* members of Nawairuku. In a similar study, McCubbin et al. (2015) conducted 40 interviews across seven villages and considered saturation to be reached after 20 interviews. A similar number was anticipated to provide sufficient information within one community for this research.

Table 4.1 *Demographic characteristics of interview participants*

Age	***Male***	***Female***	***Total***
18-24	1	0	1
25-34	2	4	6
35-44	2	2	4
45-54	3	3	6
55-64	4	2	6
65-74	3	2	5
75+	1	1	2
Total	16	14	30

Interviews were semi-structured with open-ended questions to minimise bias and allow participants to openly discuss issues they felt to be of concern and to avoid predetermination. An

interview guide included a list of thematically grouped flexible and open-ended questions reflective of the vulnerability approach which framed the *talanoa* sessions (Appendix 2). Interviews collected data on participant demographic characteristics, conditions that are affecting their lives and livelihoods and how they are coping with these conditions (Table 4.2). An embedded freelisting exercise asked participants "During your time spent in the village, what have been the biggest changes you have seen?" The question was purposely left to be ambiguous to let the participant identify changes most relevant and important to them. The freedom from predefined answering categories allowed participants to answer in their own words without prompting (Dunn, 2010; Patton, 2014). This also allowed participants to identify changes that are most visible or pressing for them individually. Semi-structured interviews are a standard method of data collection used in ethnographic research for gathering information in an open-ended format and has been widely used in community-based research with Indigenous populations (Berg, 2004; Dunn, 2010; Berg and Lune, 2012). In keeping with Pacific values and research standards reflective of the *Vanua* Research Framework (Nabobo-Baba, 2008), the semi-structured interviews were set up informally in a location suitable for the participant (e.g. at their home, outside in a shady place), were conducted as a *talanoa*-style conversation, and were conducted in the chosen language of the research participant. The interviews were conducted in English and Fijian (Ra dialect). The interviews conducted in Fijian were translated during the interview and transcripts were later verified by the local research partner. Interviews were voluntary and interviewees had the option of remaining anonymous or having their information attributed to them. Respondents also had the option of having their interview audio recorded. 30 interviews were audio recorded and later transcribed. After each interview, transcripts were reviewed and verified by the interview team. The interview quotations provided in the text are from both audio recordings and hand-written transcripts.

Table 4.2 *Interview guide highlighting key themes and example interview questions*

Theme	*Example questions*
Background information	How long have you lived in Nawairuku? Who lives in the house? How many children? Are they all in the village? If not, where and doing what?
Current livelihood activities and related stresses	Where do you get your food? How often do you do this? Where is your farm? What do you do with the produce (consume, share, sell)? How do you sell your produce? How long have you done this? Who taught you? Do you or anyone in the household engage in wage employment?
Livelihood stresses	What are the best conditions to grow _____? Are you getting those conditions? What happens when you don't get those conditions? Is there anything making ___ more difficult? How has this affected you and others?
Adaptation responses	How do you change your ways to deal with the changes conditions? Are those changes working? Is there anything that has helped you make it easier?
Past conditions affecting livelihoods	Has it always been like this? In the past when this happened, what did you (or forefathers) do? Can you still do what they did? What is different about today and why is it different? Is there anything we can learn from

	the past? Have changes happened in other communities? What did they do?
Future risks and adaptations	If the mentioned conditions were to continue, what would you do? How do you think things might change in the future? Is there anything that could help you make it easier to deal with? What could Government or NGOs do to help the village? What can villagers, themselves, do to make things better?
Concluding thoughts	Is there anything you would like to add to our discussion? Do you have any questions for me?

Two focus group *talanoa* sessions were conducted with community members during the research period. One had an agricultural focus (approx. 12 participants) while the second session had broad foci and discussed topics relating to factors that aid or constrain adaptation (approx. 15 participants). Both focus groups were conducted in Ra dialect and English in the community hall, as chosen by the participants and were led by the researcher and one research partner (Teresia Salabogi). Both sessions were audio recorded and transcribed. Complementary data gathered from participant observation and secondary sources of information were used to contextualise the information from the interviews.

4.3 Data analysis

Data from semi-structured interviews were analysed following the principles of latent content analysis to identify recurring or common themes related to the broad categories of the vulnerability approach and the research questions (Bernard, 2012). Rather than analysing interview transcripts based on exact wording as does *manifest content* analysis, *latent content* analysis considers underlying themes or messages within the interview conversation and participatory observation (Berg, 2004). Focus group data were analysed similarly with themes emerging from the transcripts. Information collected about participants was used to group participants in broad categories by gender, age, and livelihood activities. NVivo 11.4.0 software was used to organise interview data, observations and field notes. Freelisting data were analysed using salience testing calculations prescribed by Quinlan (2005) and Newing (2011). Secondary sources that were used for analysis include weather and climate data, IPCC reports, local newspapers, government and institution reports and publications, and peer-reviewed journals and were used to contextualise primary data.

4.4 Research limitations

While this research made every attempt to overcome and eliminate limitations, several were unavoidable. Vulnerability assessments, due to their necessity for local understanding and community trust and respect, often face financial, time and human resource constraints. Early ethnographers noted the necessity for field periods longer than undertaken in this research, up to several years in some cases (Wolcott, 1995). University time restrictions constrained the ability for such an extended field

period for this research, hence the ten-week field period was conducted. Due to the restricted time the research was designed to spend maximum time in one location to gain a thorough depth of understanding and knowledge of this one location. If time allowed, other nearby villages could have been involved in the research to build a more comprehensive view of climate change impacts in remote, highland region. Alternatively, a comparative case study may have been undertaken to compare locations of different characteristics (i.e. remote, highland vs. urban, coastal communities). The perspectives and stories that are documented in this thesis are those of the 30 interview participants and others who contributed to focus groups. It is likely that other experiences and perspectives could also be documented to further expand the scope of this already in-depth study. Validation of seasonal and precipitation shifts was limited due to the inadequate access to reliable weather and climate data. All efforts were made to corroborate narrative data, however, sparse weather observation stations coupled with inconsistent weather reporting resulted in the inability to use accurate instrumental weather and climate data.

While this research uncovered and discussed a wide range of themes, it was not possible to explore and investigate all themes in specific detail. Researchers with expertise in specific disciplines could have benefited the investigation into specific identified themes (such as mental health and wellbeing, river hydrodynamics, soil quality and agricultural productivity, etc.). Here exist opportunities for future research.

Chapter 5: Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji

Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji

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Abstract

This article documents and describes how people in Nawairuku village in Ra Province, Fiji, are experiencing and adapting to climate change in the context of recent socio-economic changes. The research is distinct from other climate change impacts, vulnerability and adaptation research in the Pacific Islands region in that it focuses on people living in an interior village, whereas most previous research has been conducted with people living in urban areas in the coastal zone. An analysis of data collected through semi-structured interviews with 30 villagers, participant observation, and analysis of secondary sources reveals that recent socio-economic changes are influencing how people experience and respond to climate risks. In particular, the village is exposed and sensitive to an increase in the intensity of extreme weather events, namely cyclones and flooding, with consequences for agriculture, human health and well-being, and infrastructure. Despite a long history of coping with extreme weather events, responses to recent cyclones and floods have been mostly reactionary. Land ownership, changing agricultural practices, increasing autonomy of households from the central village leadership, and aid dependency were identified as key constraints to adaptation. Entry points to support adaptation include, providing people with skills training that would enable them to collaborate with aid organisations and the government to proactively climate-proof infrastructure and agriculture in ways that are consistent with local culture and ideals.

Keywords: adaptive capacity; cyclone; flood; food security; Indigenous; Pacific Islands

5.1 Introduction

The Pacific Islands region (PIR) is widely regarded as a "hot spot" for global climate change (Farbotko and Lazrus, 2012). Biophysical changes including sea-level rise, coastal erosion, ocean acidification and increasing water and surface air temperatures have already been recorded and are expected to continue, and accelerate, in the future (Nurse et al., 2014). The risks of climate change for the Pacific Islands are significant, challenging human rights, livelihoods, health, and well-being, and food security (Barnett and Campbell, 2010). Adaptation will be unavoidable if the negative impacts are to be moderated and opportunities captured (Ford et al., 2015).

To date, most climate change research in the PIR has focused on measuring biophysical changes, with less known about how these changes translate to affect the lives and livelihoods of people and their capacity to adapt. Other research has projected potential future climate change impacts using climate models and future emission scenarios (McIver et al., 2016; Carson et al., 2016; Hanich et al., 2018). When the human system is considered in these studies it is usually done so at the

end of the study, with vulnerability measured as a residual of projected impacts minus assumed adaptations (Woodward et al., 1998; Nunn, 2013). This research has advanced our broad understanding of how people living in the PIR might experience and respond to future climate change, but it has limited use for advancing adaptation at the community scale.

While many studies about changes in biophysical systems are made at large scales, human activity is highly localised, and impacts and responses will be conditioned by local geography and a range of societal factors, including economic trends, diversity of food systems, and experience with "change" (Duerden, 2004). This requires case study research conducted at local and community scales and the inclusion of local people to identify what climate conditions are relevant and important to them and what adaptations are realistic and desirable (Ford et al., 2010). To initiate adaptation, decision makers need to know the nature of vulnerability, in terms of who and what are vulnerable, to what stresses, and in what way, and the capacity of the system to adapt (Smit and Wandel, 2006). In the climate change field, 'vulnerability' refers to the susceptibility of a system to harm relative to climatic stimuli and relates to both sensitivity to climate exposures and the capacity to adapt (Adger, 2006). Recent vulnerability assessments acknowledge that climate change is being experienced in the context of existing social, economic, political and environmental stressors that influence exposure-sensitivities and adaptations (Pearce et al., 2010). It is also agreed by many that adaptations are most effective when mainstreamed with existing disaster preparedness and resource management initiatives (Nurse et al., 2014; Robinson, 2017).

Research that has examined climate change impacts, vulnerability and adaptation at community scales in the PIR have most often done so with people living in urban or near-urban areas in the coastal zone (e.g. Pearce et al., 2018; Nolet, 2016; McCubbin et al., 2015; Sutherland et al., 2005). As a result, the dominant discourse on climate change impacts, vulnerability and adaptation in the PIR has centered on the issue of sea-level rise and coastal communities (Nurse et al., 2014). Less is known about the experiences of people living in geographically remote locations, particularly rural, inland areas. This paper uses a vulnerability framework described by Smit and Wandel (2006) to examine how people living in Nawairuku village, Ra Province, Fiji are experiencing and responding to climate change. The study considers climate change in the context of other environmental and socio-economic changes, which influence sensitivity to climate exposures and adaptation. The following sections provide a brief description of Nawairuku and the research approach and methods employed in the study. The results are then presented first for current vulnerability, and then for future vulnerability and are discussed in the context of recent socio-economic and ecological factors that aid or constrain adaptation. Nawairuku was selected as a case study because of its location in a geographically remote region in the interior of Fiji and the authors had an existing relationship with village representatives.

5.2 Case study: Nawairuku village

Nawairuku is an interior village of approximately 320 people (60 households) (100% *iTaukei*[1]) located in Ra Province, Viti Levu, Fiji, at an elevation of 51 metres above sea level (17°38'15.52"S, 178°12'51.66"E) (Figure 5.1). Fiji lies in the Southwest Pacific Ocean between 177°E-178°W and 16°S-20°S. The country comprises 332 islands with a total landmass of 18, 333km^2 and population of 884,887 (Fiji Bureau of Statistics, 2018; Australia Bureau of Meteorology and CSIRO, 2011b). The two largest islands, Viti Levu and Vanua Levu make up 87% of Fiji's total land mass and are mountainous of volcanic origin. Other islands are smaller volcanic islands, low-lying atolls and elevated reefs. Ra province is positioned in the north-east quadrant of Viti Levu and is known as one of Fiji's "salad bowls", because of the high production of root crops and *yaqona* (kava plant) (Davetta, 2017). Ra province covers an area of 1340km^2 and has two major towns, Rakiraki and Vaileka, and 89 villages, of which Nawairuku is one (Davetta, 2017).

Nawairuku is situated in a riverine valley surrounded by steep forested and cultivated hills. The land directly surrounding the village is traditionally owned by the paramount chief of the *yasana* or *mataqalis*[2], who does not reside in the village, and this limits how villagers can use the land. The *mataqalis* of the village own land approximately five kilometres away which was the initial village site before several relocations to the current site, established here around five generations ago. A tributary of the Lawaki River flows through the village, which is a tributary of the larger Wainibuka and Rewa Rivers. There are two access roads to the village: the most direct is Nasau Road via Kings Road with a bridge crossing the Wainibuka River and the second is the alternative inland route used when there is damage to the bridge. All families rely on farming and small-scale animal husbandry for subsistence and income. Commonly harvested foods include root crops (cassava, *dalo* (taro), sweet potato, yam, *yaqona* (kava plant), fruits (coconut, banana, watermelon, plantain, breadfruit, mandarin, papaya), and vegetables (tomato, cucumber, eggplant, pumpkin, *bele*, taro leaves, chillies and Chinese cabbage). Cassava, *dalo* and banana are the main cash crops. In recent years, cash crops have become a greater focus of agricultural production in the village as people try to keep up with the increasing costs of changing lifestyles and living expenses. Several middlemen service the village by purchasing produce from villagers, which they transport by truck and sell at the market in Rakiraki or Lautoka. While this is the most convenient way to sell crops, villagers receive less money for their produce than if they were to sell the crops at the market themselves which is restricted by transportation costs, limiting overall profits.

[1] iTaukei = Indigenous Fijian people
[2] Mataqali = A sub-clan; subdivision of a *yavusa; primary Indigenous land-owning unit*

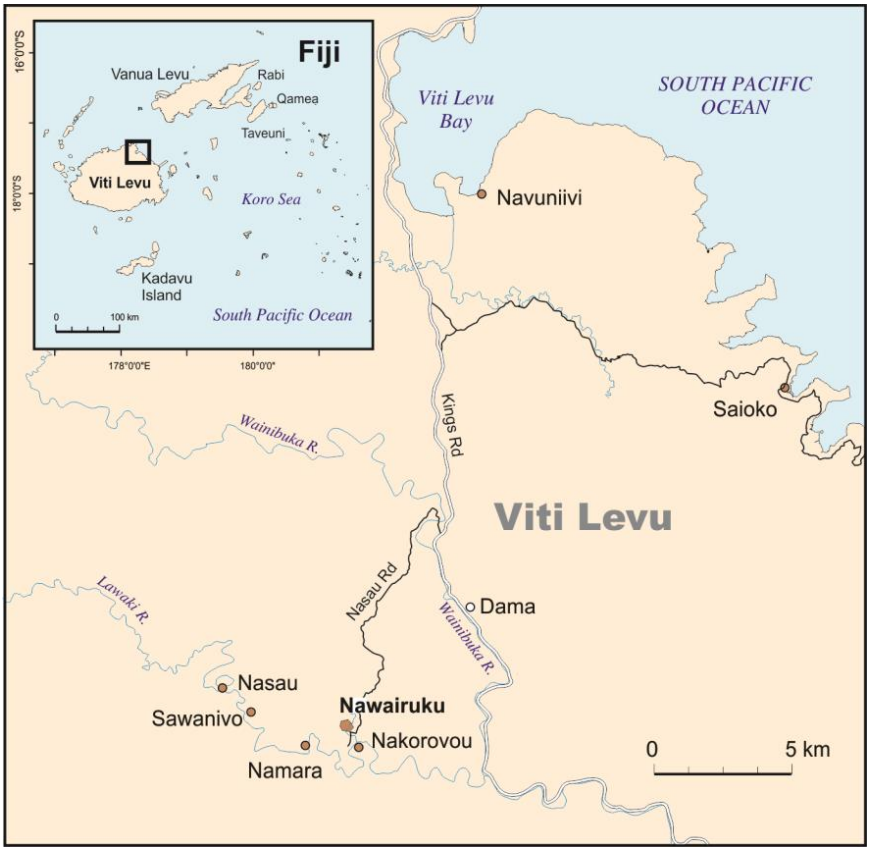

Figure 5.1 *Location of Nawairuku village in Ra Province, Viti Levu, Fiji*

5.3 Methods

5.3.1 Research Approach

The research employed a vulnerability approach consistent with the participatory community-based strategies used by Fazey et al. (2010), Leonard et al. (2013), McCubbin et al. (2015), Pearce et al. (2018), and others. Here, vulnerability is conceptualised as a function of *exposure* to biophysical changes, *sensitivity* to these exposures and *adaptive capacity* to deal with exposure-sensitivities (Smit and Wandel, 2006). *Exposure* refers to the condition of being subject to harm and reflects the biophysical characteristics of the stimulus relative to the location and nature of the system (Hewitt, 1998). *Sensitivity* refers to the organisation and structure of the system that determines the degree to which it is affected by or responsive to an exposure (Adger, 2006). Adaptive capacity refers to the potential of a system to adapt to an exposure-sensitivity, to moderate potential damages, to take advantage of opportunities or to cope with the consequences (Smit and Wandel, 2006). This conceptualisation of vulnerability is operationalised in a two-stage approach. The first stage of the approach is to identify the conditions, climatic and non-climatic, to which the individuals in a community are currently exposed and sensitive, and to document the adaptive strategies employed to deal with these conditions. This involves community members identifying those conditions that are relevant and important to them, beyond those identified *a priori* by researchers. The second stage assesses future vulnerability by considering possible future changes in climatic conditions and the capacity of the community to adapt to such changes.

The research was guided by consideration for conducting research with Indigenous peoples described by Nabobo-Baba (2006; 2008) and Pearce et al. (2009) and regulations for conducting research in Fiji outlined by the Department of Immigration (Fiji Department of Immigration, 2017). Early communication was first established in February 2017 by phone and E-mail with the Chairman of the Village Development Committee, the *turaga-ni-koro* (village spokesperson), Office of the Commissioner Western in Lautoka and Ra Provincial Council to introduce the research idea (Appendix 3). Then, on invitation from the *Ratu* (chief), the researchers, together with village relatives, visited Nawairuku for two days in April 2017 to conduct a *sevusevu* and discuss the proposed research. Upon confirming support for the research, the researchers returned to Australia and prepared applications for a research license and ethics approval. Approval for the research was granted by the Fijian Department of Immigration (#I7497899) and study protocols were approved by the Human Research Ethics Boards at the University of the Sunshine Coast (A/15/751) and University of the South Pacific. The researchers returned to Nawairuku in June 2017.

5.3.2 Data collection

Data for this paper were collected over a 10-week period between June and August 2017. Multiple data-collection techniques were used, including semi-structured interviews using open-ended questions (n=30), focus groups (n=2), participant observation, and analysis of secondary sources (government documents, climate data, published and unpublished research). Key informant and snowball sampling techniques were used to identify interview participants starting with key informants (village head person, local research assistant) who then assisted in identifying a cross-section of the adult population in Nawairuku (Table 5.1) (Patton, 2014). In particular, long-term residents of the community or who are particularly knowledgeable about history of change were identified. Sample size was determined by reaching a point of saturation (n=30). All 30 participants were *iTaukei* and resided in Nawairuku. In a similar study, McCubbin et al. (2015) conducted 40 interviews across seven villages and considered saturation to be reached after 20 interviews. A similar number was anticipated to provide sufficient information within one community for this research.

Table 5.1 *Demographic characteristics of interview participants*

Age bracket	***Male***	***Female***	***Total***
18-24	1	0	1
25-34	2	4	6
35-44	2	2	4
45-54	3	3	6
55-64	4	2	6
65-74	3	2	5
75+	1	1	2
Total	16	14	30

Interviews were semi-structured with open-ended questions to minimise bias and allow participants to openly discuss issues they felt to be of concern and to avoid predetermination.

Interviews collected data on participant demographic characteristics, conditions that are affecting their lives and livelihoods and how they are coping with these conditions (Table 4.2). Semi-structured interviews are a standard method of data collection used in ethnographic research for gathering information in an open-ended format and has been widely used in community-based research with Indigenous populations (Berg and Lune, 2012). In keeping with Pacific values and research standards reflective of the *Vanua* Research Framework (Nabobo-Baba, 2008), semi-structured interviews were set up informally in a location suitable for the participant, were conducted as a *talanoa*-style conversation, and were conducted in the chosen language of the research participant (English and Fijian (Ra dialect)). The interviews conducted in Fijian were translated during the interview and transcripts were later verified by the local research partner. Interviews were voluntary and interviewees had the option of remaining anonymous or having their information attributed to them. Participants also had the option of having their interview audio recorded. 30 interviews were audio recorded and later transcribed. After each interview, transcripts were reviewed and verified by the interview team. The interview quotations provided in the text are from both audio recordings and hand-written transcripts.

Two focus group *talanoa* sessions were conducted with community members during the research period. One had an agricultural focus (approx. 12 participants) while the second session focused on factors that aid or constrain adaptation to changing conditions (approx. 15 participants). Both focus groups were conducted in Ra dialect and English in the community hall, as chosen by the participants and were led by the researcher and local research partners. Both sessions were audio recorded and transcribed. Complementary data gathered from participant observation and secondary sources of information were used to contextualise the information from the interviews and focus groups.

5.3.3 Data Analysis

Data from the semi-structured interviews were analysed following the principles of latent content analysis to identify recurring or common themes related to the broad categories of the vulnerability approach and the research questions (Bernard, 2012). Rather than analysing interview transcripts based on exact wording as does manifest content analysis, latent content analysis considers underlying themes or messages within the interview conversation and participatory observation (Berg, 2004). Focus group data were analysed similarly with themes emerging from the transcripts. Information collected about participants was used to group participants in broad categories by gender, age, and livelihood activities. NVivo 11.4.0 software was used to organise interview data, observations and field notes. Secondary sources that analysed to help contextualise interview and focus group data included weather and climate data, Intergovernmental Panel on Climate Change (IPCC) reports, local newspapers, government and institution reports and publications, and peer-reviewed journals.

5.4 Vulnerability to multiple stressors

5.4.1 Changing exposure-sensitivity

In Nawairuku, a combination of changing climatic conditions and changing socio-economic conditions manifest to affect lives and livelihoods. Table 5.3 presents a list of conditions identified by participants, the frequency with which each was mentioned, a brief description, and a sample quote from participants. It is noteworthy that the village was directly impacted by Tropical Cyclone (TC) Winston in February 2016 and endured a record-breaking flood the December prior. As such, it is to be expected that participants frequently referred to these events during interviews and focus groups.

Table 5.3 *Conditions affecting lives and livelihoods in Nawairuku*

Condition (% of participants)	**Description of condition**	**Sample quote(s)**
Rising living costs (93%)	Rising living costs, fluctuating agricultural markets and limited employment opportunities are resulting in financial hardship.	*Now, it is too expensive and what you get out of a plot is not enough for your living. Everything is very expensive in town and what we plant here is not enough. But before if you plant around here you will get more than enough. It's not enough now because there are more expenses and everything is more expensive. And what they want out of the crop, the crop is not giving the full amount they need. Before, they plant it, they get what they want, and life then was not that expensive*. (Jone Sokiveta, 51 years, August 2017)
Changing agricultural practices (57%)	More intensive agricultural practices are being used to engage in the commercial economy; intensification of agriculture including use of agrochemicals to create surplus crops; degraded agricultural lands.	*They use the spray the same to kill bugs on the watermelon. It works to catch prawns. If I use the liquid in the river it will take one or two years, three for the prawns to come back because of the poison in the river. It can affect the fish too. Some use duva…. Duva grows here. People didn't do that before… People used to attack those prawns with the poison. People just do it for their food for now without thinking about the future.* (Netani Salaba, 19 years, July 2017)
Rapid population growth and localised development (47%)	Rapid population growth and localised development are stressing local natural resources.	*Before they had bushes and forest here, over the hills, there used to be big trees; now we don't have it. Before there was just a few people living in the village so there was not as much planting and farming. Now, there are so many in the village and we have little space so the reason for the cutting down of trees is for farming and they use that space for farming.* (Leone Naimawi, 64 years, July 2017)
New building styles (40%)	Building styles have shifted from traditional *bures* to modern tin and timber houses. Modern architecture is not suited to the Fijian climate and poses health hazards during cyclones as iron is dislodged.	*This cold season, in the old days, in the bure you have the fire going so when it is burning you will feel heat and you won't even notice it is very cold. Now since we live in the tin house, sitting in the kind of area you can feel cold, and he can feel cold when he is with us. There is no heat coming out of the [kerosene] fire. But the heat in the bure, it stays. Before, we have traditional culture that keeps us warm up all together.* (Penisimani Rabenawa no. 2, 29 years, July 2017) *It was really dangerous during the cyclone. You see the iron roof flying from this side, hitting another house, just flying around. They peel of the roof. This happened here*. (Epeli Raisevu, 58 years, July 2017)
Water security (20%)	Fresh water resources are limited in capacity and transportation infrastructure is sensitive to extreme weather events. This has negative implications for human health, and agriculture.	*As you can see there's no water coming sometimes… off and on in the taps. Because the tank was also affected. After Winston, Luke went up there and all the dam was bad, it got damaged. So, they need to buy another one. From that time until now they couldn't buy those dam, because you know, it's expensive. Luke went up they cut the stick just for the time being. That's why the water is on and off. It's just for temporary. Luke has been trying to go to the plumber to come and see the water. They say they will come but we keep on waiting until today. Maybe after the election.* (Female participant, 28 years)

Geographic isolation (13%)	Isolation from urban centres and towns reduces access to markets and services.	*One difference is, because they are near to the town, and for us here, is our fare. We spend $20 fare from here to town and come back. For those living near town they spend just $2, get in the bus, get to town. That can be one of the major differences. That makes it more difficult to get to town and sell produce at markets. If we take our produce to the market we have to pay another fare for the cargo as well.* (Group *talanoa* participant)
More intense cyclones (90%)	Older participants (<50 years) reported cyclones no longer strictly occur during cyclone season and are more intense. TC Winston was the most intense cyclone to ever make landfall in the southern hemisphere.	*That's the first hurricane like that. Before, 1972 when I'm in school there's some hurricane, Hurricane Bebe…1992, Hurricane Kina, that's a big one too. But that hurricane never take away our house, just push the iron roof to one side but never take it away. But this one… some iron roof was torn away like paper. Very strong. This is the biggest one... Changing of the weather is very fast. From 2000 until now. Very, very fast! Change is happening.* (Epeli Raisevu, 58 years, July 2017)
Less distinct wet and dry seasons (70%)	Timing of seasons is less predictable and are no longer at the "right time", that is, the same time of year their forefathers knew. Precipitation and temperatures fluctuate throughout seasons.	*The amount of rain in wet seasons has changed. It's because of dry seasons where we have little by little rain. Before when it was cold/dry season you wouldn't get rain. When it is dry season it is dry throughout. Only in December you will be expecting rain. But now it is coming in between, raining, sunny, rainy, sunny. But it shouldn't be like this. This has happened like this for the past two years.* (Emele Koronawa, 50 years, July 2017)
Altered river dynamics (70%)	The river is more shallow and narrow than past averages of 10+ years ago; less tree coverage and riparian vegetation.	*Before, they know where the water level is, where its deep and where its shallow and the place to cross. But now, you can cross anywhere because it is shallow. This started to change in the 80s. That's when the water started going down.* (Sanaila Vakaravia, 67 years, July 2017)
More extreme floods (53%)	A record-breaking flood associated with Tropical Depression TD04F on 17 December 2016.	*After the flood, crops were damaged. They got too wet in the soil. The one that is planted near the river, they were just carried away by the flood*. (Ema Duribalavu, 31 years, July 2017) Ema
Slope instability – landslides (30%)	Intensification of farming prompted the clearing of trees for agricultural land; heavy rainfall events trigger landslides. The first landslides were recorded in 2004 and damaged buildings in the village.	*The big slide you can see at the high places on the side of the school. Before, in 2005, there's a big slide here on the school side on top of the hill here, big slide here. One hostel for the boarders was damaged. After one year it was given by government, it was damages. About 30 children were staying there, just send the children to go to the village on a Friday and about 15 minutes after they leave, the slide comes, brings down the big trees, stone, soil and water, over that block house. Lucky the children were gone.* (Epeli Raisevu, 58 years, July 2017)

5.4.1.1 Changing socio-economic conditions

Many socio-economic conditions were identified as factors, which together with climatic stressors, are affecting lives and livelihoods in Nawairuku. 93% of participants (n=28) identified rising living costs as a driving force of stress. Rising living costs have put financial pressure on families in Nawairuku prompting people to find new ways to increase their household income in order to meet demands. Rapid population growth and localised development adds further pressure on the

natural resources and carrying capacity of the area. The village was established at the current site in the late 1800s with four or five houses, which exponentially grew to the 60 houses today. Over time, building styles have shifted from traditional one-roomed thatched *bures* to modern timber and iron houses. Traditional *bures* could regulate ambient temperatures to suit the tropical climate of Fiji, keeping houses cool during hot weather and retaining heat during cooler weather. Modern architecture does not have these features and some building materials like tin are a hazard during cyclones.
The freshwater system for the village has a limited capacity and is sensitive to changes in precipitation and extreme weather events. Water for the village is sourced from a reservoir created by a small concrete dam in an upper valley approximately 2.8 km from the village and accessible only by horseback and foot. Water is piped to a central water tank near the village before being distributed by pipes to individual households. During dry periods, water supply is often cut to the village due to limited water in the communal village tank. In addition, severe weather events often cause structural damage to the distribution system and there is limited ability (parts, expertise, labour) to facilitate necessary repairs.

The geographic isolation of the village from urban centres results in some challenges not experienced by near-urban villages including, physical distance from markets, goods and services, education and employment opportunities, and lack of rubbish collection services. These conditions limit villagers' ability to partake in some livelihood activities such as selling goods at the market, purchasing grocery items from the store, attending workshops and trainings, engagement in wage employment while retaining family presence, and accessing basic health care services.

5.4.1.2 Changing climatic conditions

In many instances, existing climatic stressors have intensified and become more common in recent years. 90% of participants, (n=27) described changes in the timing and intensity of cyclones. Notably, recent cyclones have inflicted greater damage on infrastructure and agricultural assets (land, crops) than past cyclones. Older participants (>50 years) shared that recent cyclones (e.g. TC Winston (2016)), and the damage that they caused, were of a magnitude that they had never experienced before. 70% of participants, (n=21) observed changes in the timing of seasons. In Nawairuku, seasons refer to the wet season, dry season, and cyclone season. Older participants (>50 years) described that in the past seasons came at the “right time”; the time that they expected based on past experience. Now, seasonal characteristics – precipitation and temperature – occur at any time of year and are increasingly unpredictable. Participants recalled seeing too much rain in dry seasons, and vice versa. While some older people still rely on traditional knowledge to forecast weather, some participants explained that this knowledge is becoming less reliable due to changing conditions. 70% of participants (n=21) observed changes to local rivers. It was noted that the river has changed course and is now shallower than it was 10+ years ago, with implications for infrastructure, agricultural land and aquatic food sources. The structural integrity of riverbanks is jeopardised by erosional processes

and houses built atop these banks are at risk. There are fewer fish to eat and the water quality has declined posing health risks to people who use the river to bath.

Approximately ten months after TC Winston, Nawairuku endured a record-breaking flood associated with a slow-moving tropical depression (TD04F), the first of the 2017/18 cyclone season (ReliefWeb, 2016). Floodwaters rose rapidly on 17 December 2016 at a time when the community was rebuilding homes and re-establishing farmland. Flooding caused widespread destruction; it damaged infrastructure and transportation routes to the village, and ruined cultivated land.

5.4.2 Where does climate fit?

This section describes the ways in which climatic stressors are woven into the fabric of the underlying socio-economic conditions in Nawairuku. The main areas of vulnerability to changing climatic conditions can be summarised as agricultural productivity, human health and well-being, and built infrastructure. Each of these interrelated sectors are exposed and sensitive to climatic changes (Figure 5.2).

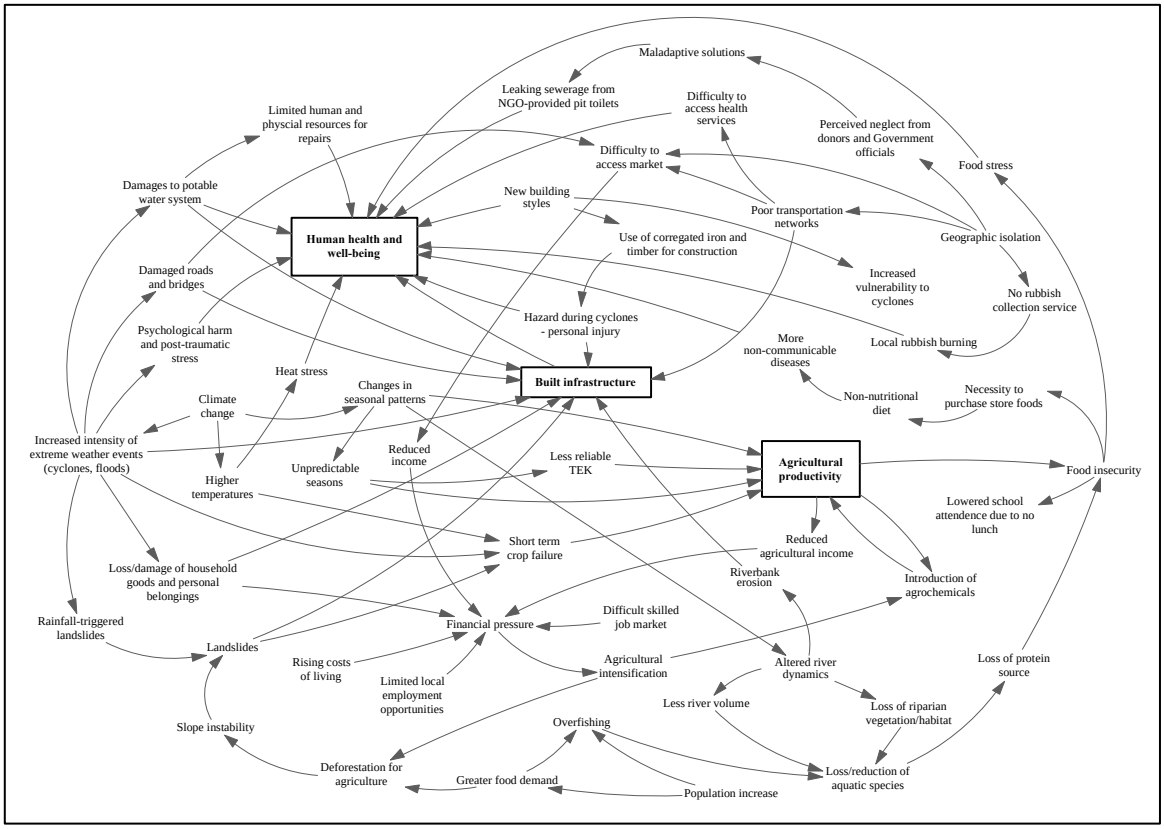

Figure 5.2 Systems diagram showing the complex interactions of climatic and non-climatic conditions that affect the vulnerability of agricultural productivity, human health and well-being, and built infrastructure in Nawairuku to climate change.

5.4.2.1 Agricultural productivity

Agricultural productivity is measured as a ratio of agricultural outputs to agricultural inputs. Traditionally in Nawairuku, people grew root crops, fruits and vegetables for subsistence and did not sell any produce. It was considered *tabu* (taboo) to sell root crops and the forefathers never engaged in

this practise. Today, however, people are intensifying agricultural production and selling root crops to middlemen and directly to customers at the Rakiraki and Lautoka markets. Some older participants claim this new system of selling root crops is the cause of decreased tuber sizes and reduced overall productivity. Cassava, *dalo*, banana and *vudi* (plantain) are the most common cash crops. Other root crops, fruits and vegetables are grown for subsistence and small volumes are sold.

Agricultural productivity is exposed and sensitive to extreme weather events, changing seasonal patterns, and new farming practices such as the commercialisation and intensification of agriculture and increased use of agrochemicals. Increased intensity of extreme weather events including cyclones and floods have damaged agricultural land and destroyed crops. Most recently, TC Winston, a category 5 cyclone, caused immense damage to agricultural land when it passed over Nawairuku on the 20th of February 2017. Winds up to 300km/hr, heavy rainfall and flash flooding caused physical damage to agricultural land, including landslides and tuber waterlogging, which destroyed most crops (NASA, 2016). Participants reported losing whole harvests of *dalo*, cassava, *vudi* (plantain), and *uvi* (yam) and the expected income they would have earned by selling the produce. Similarly, during the December 2016 flood, some villagers lost plots of land that were simply washed away by floodwaters. The fertile, moist soils near the river are an inviting location to plant short-term crops and *dalo*; however, plots located here and near village drain systems are especially sensitive to flooding.

Slope stability and landslides are also an issue of concern for villagers. The first reported landslide occurred in 2004 and there is no memory of landslides in the area prior to that event. In recent years, intensive forest clearing has occurred on the slopes surrounding the village site for the cultivation of root crops, reducing the stability of the slopes. During TC Winston, landslides were triggered by heavy rainfall which saturated the relatively loose soils and prompted weakness in the slope stability. Agricultural plots were completely lost following the landslide events and fertile soil was stripped from the hillside. Areas that had never flooded before were inundated and some crops were washed away by floodwaters or damaged by rainfall-triggered landslides. Damaged roads further restricted access to markets and services. The flood destroyed the bridge on Nasau Road that crosses the Wainibuka River to access the village from the east, forcing villagers to rely on small boats to cross or take the alternative route, which is three hours longer, to Rakiraki.

Shifting seasonal patterns (rainfall and temperatures) disrupt growing seasons and reduce agricultural productivity and subsequent income. Short-term crop failures have been observed in response to unseasonal rainfall damaging new crop shoots or waterlogging tubers. Participants have observed wet and dry seasons becoming less distinct, recalling that in the past seasons were separate and they could predict wet and dry periods at given times of year.

> *They have the months for the seasons – wet and dry. Before, when the seasons come, it doesn't affect the crops. But now, the changes of the weather, it changes the crop especially the size of the crop. Before, when it is wet or cold, when they plant the crops they give the right size but now no*

more because the change of the weather comes any time. The size gets smaller. Before there was no effects on the crops. (Sanaila Vakaravia, 67 years, July 2017)

The use of agrochemicals has intensified in response to these and other changes affecting agriculture with possible consequences for human health and longer-term soil productivity. Villagers are unsure of the long-term impacts of agrochemicals use but opt for a short-term solution to deal with decreasing yields and rising living costs.

We don't have to use the chemical for the grass because that will affect the soil. It can affect us too, when we use those chemicals. The soil mixed with the chemical and we plant the melon or dalo and the chemical goes in that and can affect our bodies. You have to go with time. I use chemicals for the weeds because we can't do weeding on 1 or 2 acres because it's a lot of land. We want to use plenty lands like that so we have to use the chemicals. Or if you want to earn the big money you use the chemicals to help the farm. (Masake Baisagale, 51 years, July 2017)

5.4.2.2 Health and well-being

Health and well-being in Nawairuku have been affected by both rapid and gradual climatic changes. Extreme weather events such as cyclones and floods have resulted in increased incidences of illness, injury and mental health concerns; gradual changes such as biodiversity loss, prolonged dry periods, and extreme heat have contributed to declines in agricultural productivity and overall food security.

There were several instances of illness and injury in Nawairuku during TC Winston and recent flood events. Following TC Winston, one woman fell sick and was bedridden for a week with boils rising on her skin due to unhygienic conditions, being constantly wet from cleaning, poor nutritional intake, and lack of clean drinking water. She believed the main reason people got sick was because of the damaged pipes and inability to access clean water for drinking and bathing. Others suffered cuts from iron roofing that was torn from housing by high winds and everyone experienced extreme exhaustion. Flood events have also negatively affected people's health due to a shortage of clean drinking water and exhaustion from extensive clean-up efforts.

I got sick. Just fell sick, exhausted. Just had to stay home again for another week. And I had all this, this is from Winston, all these black marks. They are just small sores like a boil all under my breast. That was after cleaning up, the week after Winston. Just from cleaning up and due to unhygienic and being wet and because our lives were changed. And most of the time we were washing and not eating properly and being wet. And the water was, the taps were down but lucky the creeks and the streams were flowing so we were using that. Yeah, I got sick after that, stayed home for a week. (Kalara Veramu, 40 years, August 2017)

The river is a vital source of food and water and even minute physical changes affect the lives of villagers. Several aquatic animal species were recorded to live, or once live, in the river flowing through Nawairuku. Species include *Maleya* (tilapia, *Oreochromis niloticus*), freshwater eel (*sp.)* and prawn (*sp.*). Each of these species served as an important source of protein for human consumption. Many accounts of aquatic biodiversity loss were documented. The decreased abundance and size of these species contributes to a less secure food system. Participants noted the absence or lower

abundance of fish (*Maleya*), prawns and eels as well as the reduced size of remaining stock. One participant explained that ten years ago one could catch fish the size of a forearm but now the biggest size fish are around the size of an adult hand. Similarly, ten years ago it was possible to lift large stones from the river edge and uncover "*plenty*" of prawns but now it is uncommon to see any prawns at all.

> *Before, it was very deep and plenty fishes here but it's getting dry now. Big fish here so we can just go here, take the fishing net, catch fish, any time you go to the river. Nowadays it's very hard. People go to the big river now. You can't get the big ones in this river now. Now only small ones. Hardly to get big ones*. (Viniana Salabogi, 52 years, July 2017)

Recent cyclone and flood events also inflicted an emotional and mental toll on villagers. The shortage of fresh and non-perishable food following TC Winston and flood events affected people's health and well-being by reducing access to nutritious foods and causing food-stress. Households depended on each other to ration and share existing food supplies for the month before food aid arrived following TC Winston. One participant (F, 52 years) recalled her psychological struggle to comprehend and deal with the onset of the recent flood that threatened to damage her house after recovering from TC Winston.

> *The big flood was in December [2016]. We have to do a big cleaning up again. When all the boys came here I didn't think the flood was going to come inside here. Only those people at the back there but it came in. When Kini told me, the water was starting to come up from that side. Simeli's school bag was swept away by the water. Kini just got all the boys to take all the stuff up. The clothes, like that, Jo's suitcase. Some other things. I don't want to go and take anything up. Like I'm growling or what? I was thinking of the cleaning up, it's very hard. Only Kini and the boys take the things, I don't want to, I just sit here and look at them. Big job, big job.* (Viniana Salabogi, 52 years, July 2017)

An elderly man suffered a stroke the day after the flood upon visiting his house and seeing the intense damage throughout. He passed away in May 2016, several months after his first stroke. His daughter explains how it happened:

> *He just came, came from that door, the one that you entered I think he just saw everything all over the place and he lied straight down… That's where they start, one side, something like a stroke, all the left side of his body gets like shocked. That's when his sickness started. He just goes down slowly and lied down… They said it was the first stage of a stroke*. (Female participant, 30 years, July 2017)

5.4.2.3 Built infrastructure

Built infrastructure in Nawairuku, including houses, community dwellings, water and power distribution systems, roads and bridges are exposed and sensitive to cyclones and floods. The traditional one-roomed, thatched roof, earth floor *bure* proved its ability to withstand the elements of extreme weather events such as high velocity winds and heavy rainfall (Fujieda and Kobayashi, 2013). The move towards Western housing styles, however, saw the replacement of traditional *bures* with contemporary houses constructed from newly introduced materials (iron sheet roofing and walls, wooden frame) in the latter half of the 20th century (Fujieda and Kobayashi, 2013). This transition saw

the complete loss of *bures* in Nawairuku and with it, the comfortable, climate-suitable designs that were more resilient to extreme weather events. One participant shared how his "*iron roof was torn away like paper*" during TC Winston (M, 58 years). Modern building materials, like tin, can become lethal hazards as they are blown around, potentially causing serious harm or death.

> *It was really dangerous during the cyclone. You see the iron roof flying from this side, hitting another house, just flying around. They peel of the roof. This happened here*. (Epeli Raisevu 58 years, July 2017)

> *Because some just died in their homes even around here. One just down here, they died in their house… one nursing mum down there. Because when the cyclone came they wanted to run it was just no time to run, one iron came flying and just cut her stomach.* (Kalara Veramu, 40 years, August 2017)

A total of sixty-two houses sustained damage during TC Winston that was significant enough to be eligible for government funds for rebuilding. The Fijian Government offered vouchers of varying values to purchase construction materials. 42 houses were "fully destroyed", 9 houses sustained "full roof damage" and 11 houses sustained "partial roof damage". These homeowners received FJD$7000, FJD$3000 and FJD$1500, respectively. This dataset was obtained from kept records from the *turaga-ni-koro* (village headman) who recorded the damage to deliver to authorities for recovery compensation. Many residents were in the final stages of rebuilding their houses after TC Winston when floodwaters ravaged the village in December 2016. While the floodwaters incurred no structural damage to houses, the clean-up effort was phenomenal. Layers of mud up to two feet thick carpeted the inside of houses, smothering whitegoods, kitchen tools, woven mats, bedding, clothes, and other household belongings. Like individual households, communal infrastructure and community dwellings have also been damaged during recent cyclones and floods. Landslides on the cultivated slops surrounding the village caused damage to school infrastructure including the headmaster's quarters and boarding dormitory.

> *The big slide you can see at the high places on the side of the school. Before, in 2005, there's a big slide here on the school side on top of the hill here, big slide here. One hostel for the boarders was damaged. After one year it was given by government, it was damages. About 30 children were staying there, just send the children to go to the village on a Friday and about 15 minutes after they leave, the slide comes, brings down the big trees, stone, soil and water, over that block house. Lucky the children are gone.* (Epeli Raisevu, 58 years, July 2017)

High volumes of water associated with heavy downpours threatens houses located atop vulnerable river banks. The stability of the river banks is being undermined by erosion processes in two locations: one where 15 houses are built and the other where one house is becoming nearer to the edge.

> *When there is heavy rain and flood, that part of the bridge sometimes washes out. But it is too dangerous for the trucks because the water is fast. Sometimes they drive through it and sometimes they don't, depending on the water level. It is very difficult without the truck access. There is another way to come from another road to the village but it is very expensive because it is very far. You have to go all the way and come up that way. You have to go further up.* (Maria Moce, 28 years, July 2017)

5.5 Current adaptive strategies

People in Nawairuku have a long history of coping with change and are employing several measures to deal with current climate-related exposure-sensitivities (Table 5.4). Adaptations are organised and described here based on the timing of the action: *proactive adaptations* are anticipatory actions that are implemented ahead of stimulus and intend to avoid or reduce harmful impacts and/or benefit from opportunities (Smit and Pilifosova, 2003); *concurrent adaptations* are actions that occur during stimulus though gradual and ongoing changes in climatic norms; and *reactive adaptations* occur in response to stimuli and are undertaken after impacts are apparent, often unplanned.

Table 5.4 *Current adaptive strategies*

	Adaptation	Classification	Description
Agriculture	Planning for food security	Proactive	Plant fast-growing root crops in November to have available harvests during cyclone season Implemented of planting programs to ensure a consistent harvest and income year-round Planting fruit trees around houses to provide easily-available food
	Department of Agriculture Workshops	Proactive	Participation in NGO- and Government-led workshops and trainings to learn about climate-resilient crops, use of agrochemicals, farming techniques
	Altered farming practices	Concurrent	Intercropping: cultivating two or more crops together to take advantage of available space and be more time- and effort-efficient. It is also known to potentially improve soil health and fertility Crop rotation: growing different crops in succession on a piece of land to avoid exhausting the soil of nutrients and to control weeds, pests and disease. The ultimate purpose is to maximise yield Drainage: dug trenches adjacent a plot to guide excess moisture away from dry-soil crops. It is common for the practice to occur where *yaqona* (kava plant), ginger, *kumala* (sweet potato) are cultivated Timing of operations: Changing planting and harvesting times in response to changing growing seasons to decrease crop rot Strategic land use: Taking advantage of humid, moist soils located in the densely forested hills surrounding the village where wet season crops are grown through the dry season to capture high market prices
	Relocation of farm plots	Reactive	The relocation of agricultural plots away from high-risk areas (flood- and landslide-prone areas) such as the levees and banks for the rivers and the slopes of surrounding hills
Health and well-being	Capturing extra income opportunities	Concurrent	Crop diversification and adoption of hybrid species Off-season production to capture high market values Engagement in off-farm activities such as creation of handicrafts (woven mats, fans to sell at markets as a 'Plan B') Engagement in wage employment to supplement household income Community fundraising events (e.g. by hosting sport tournaments)
	Drawing on kinship networks	Concurrent	Supporting elderly residents by providing food, firewood Sharing grocery goods in times of stress (after TC Winston, floods) Lending/borrowing fishing equipment and repaying in caught fish

Built infrastructure	Staying prepared	Proactive	Some participants continue to have cyclone preparation strategies in place throughout the year. Such strategies include makeshift bracing of roof beams and iron sheets
	Carpentry workshops	Concurrent	Participation in NGO- and Government-led workshops and trainings to learn about cyclone-resilient building designs Implementation of improved building standards to strengthen the structural integrity of houses
	Altering layout of new houses	Reactive	Strategically rebuilding houses to avoid wind tunnels, and lessen wind resistance and uplift force during cyclonic winds Positioning houses so the narrow end faces into prevailing winds
	Relocation of houses	Reactive	Rebuilding houses away from the flood-prone areas near the river and landslide-prone areas on sloped land

5.5.1 Agricultural productivity

Maintaining a sustainable agricultural production system is a key to food security Nawairuku. Participants shared their methods of planning ahead to ensure food security in potential times of stress and their newly developed planting program implemented to ensure a consistent harvest and income year-round. In terms of planning ahead, some people are planting more fruit trees around their houses to provide food and shelter in the future. The newly developed planting program was initiated from workshops by the Ministry of Agriculture on new farming techniques and agrochemicals. The program includes new considerations for intercropping, crop-rotation, drainage, timing of operations and strategic land use (Table 5.4). Villagers have also relocated agricultural plots from flood-prone areas to the steep slopes of the surrounding hills. This has reduced the vulnerability of agricultural land to flooding but has created new problems through landslides.

> *The places they used to plant now they can no longer plant there. They had to change place because of the river because they don't know when it will be very high and the river has affected the area… The area where the crops used to grow has now slid. This happened in really bad weather events and heavy rain. This started happening in 2004. When this started happening they started to move up to the forest where everyone is planting now.* (Emele Koronawa, 50 years, July 2017)

5.5.2 Health and well-being

Familial relationships and sharing networks are key sources of adaptive capacity to cope with and recover from cyclone and flood events. Fellow villagers and kin provide material assistance and help in the form of food, shelter and labour to affected families while expatriate kin (professional rugby players, migrated workers) tend to send money. The village supports elderly residents and once a person can no longer physically to tend to their farm themselves, direct and indirect relatives provide food and give assistance for home maintenance. Informal sharing networks facilitate the sharing of equipment such as fishing nets, with the borrower sharing part of the catch. Participants are also using new tactics to access income to support rising living costs. These include: crop diversification, capturing off-season crops high market price, engaging in off-farm activities (sale of handicrafts), rural-urban migration to seek work in urban centres, and holding community fundraising

events. Most of these strategies are focused on short-term outcomes with little, if any consideration for longer term trends in climate and society.

5.5.3 Built infrastructure

A key lesson learnt following the extensive damage and destruction to most of the houses in Nawairuku during TC Winston was the inadequacy of building standards to withstand the force of a Category 5 cyclone. In response to this, government and non-governmental organisation (NGO)-led carpentry workshops have been held in the village and focused on building more resilient structures. For example, carpenters are noting the direction of trade winds and are positioning houses to minimise exposure to strong winds during cyclones. In addition to new building techniques, some houses have been relocated outside of the flood-plain to reduce their exposure to flooding.

> *When it is a normal day, normal weather, when you start rebuilding houses you try to build it in a way for another cyclone that will hit, it won't take away the whole thing. Once you rebuild, build in a way to hold on and withstand it… Now they faced it this way to be streamlined against the wind. If you see the setting of the houses, they all face this way. When Winston came, the house was this way the wind came from that way and blew the house. Now they face the house this way so less wind will be against the walls. The strong winds always come that way*. (Ananaisa Namatua, 59 years, July 2017)

5.6 Future vulnerability

5.6.1 Future exposure-sensitivities

Exposure-sensitivities and adaptive capacity are dynamic and will change as the social makeup of the community and climate change over time. People in Nawairuku are currently sensitive to climate-related changes and natural disasters that threaten subsistent agriculture, infrastructure and accessibility, and human health and well-being. These conditions are projected to continue in the future with further implications for lives and livelihoods. It is not possible to predict future changes with certainty but we can use current exposure-sensitivities and adaptation strategies as a baseline to consider future trends in climate and society.

Without access to informed climate models and projections, it is difficult to envisage what future climatic and geological scenarios might look like. Despite this, participants used past events to project a future scenario for Nawairuku (Table 5.5). Outlooks on the future were based on past events, government updates and bible verses. Predictions include more intense cyclones, more landslides, the continuation of the river becoming drier, increased population and development, more land clearing to build new houses and people's attitudes reflecting Western cultures.

Several of the future conditions identified by participants are supported by future climate change models. Key sources of future climate change projections are the IPCC 2013 reports (Stocker et al., 2013) and the Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation's scientific assessment of climate change in the Pacific (Australian Bureau of Meteorology and CSIRO, 2011b). These projections are for the broader geographic region in which

Nawairuku is located and include the Fiji Islands and surrounding oceans. Projected changes in rainfall in the Pacific Islands region will significantly alter the hydrological cycle altering the pattern, frequency and intensity of rainfall events. While wet-season rainfall is projected to increase, dry-season rainfall is projected to decrease and there is a high confidence that the occurrence of extreme rainfall events will increase (Australian Bureau of Meteorology and CSIRO, 2011b; Stocker et al., 2013). Surface air temperatures are projected to increase as are days of extreme heat (Australian Bureau of Meteorology and CSIRO, 2011b). While the frequency of cyclones is projects to remain stable or decrease, the intensity of cyclones is likely to increase. These climatic changes could have several implications for many communities in the Pacific Islands region, and in the case of Nawairuku, for the current exposure-sensitivities identified in this paper.

Extreme weather events have already resulted in the loss of agricultural land and crops in the wake of cyclones, floods and landslides. A projected increased occurrence of intense rainfall events would further contribute to the degradation of agricultural land by escalating overland flow and surface runoff (Nelson et al., 2009). Furthermore, increased temperatures and enhanced moisture deficits could increase stress on crop production, income and food security (Nelson et al., 2009). Similarly, increases in inter-annual variability and intensity of extreme weather events could impact agricultural productivity and may result in further complete crop failures, significantly affecting household food security. The community's seasonal vulnerability to potable water scarcity would become more exaggerated if projected decreases in dry-season rainfall materialise. Intense rainfall events will provide more rain over a shorter period but will be of no assistance in potable water accumulation as the village dam can only harbour so much water at a given time. Additionally, high-rainfall events in the past have proven to incur damage to the water pipelines and distribution grid.

Of course, changes in climatic conditions will not be experienced in isolation, but together with changes in political, economic and social conditions in which Nawairuku operates. An expected increase in population will put further pressure on the local natural resource base raising questions about carry capacity under current agricultural practices and water system. The potential stress on food and water sources increases, together with other societal factors, could increase the incidence of illness and nutrition-related diseases. Changes in exposure-sensitivities in a future climate scenario will likely have a detrimental effect on the financial situation and overall well-being of residents as household income sources are reduced.

The projected increased frequency and intensity of extreme weather events will threaten the integrity of built infrastructure including houses, community dwellings, water and power distribution systems, and roads. Damage inflicted by floods, landslides and cyclones has already been experienced and is likely to occur again under future projections, particularly if residents do not apply lesson learned and climate-proof infrastructure.

Table 5.5 *Community participant future predictions for Nawairuku*

Prediction	Comments
More cyclones	*Before Winston, normally they come every 4 years or 3. Before Winston I think there was a cyclone four years back, Cyclone Evan. Not as strong as Winston. Only Winston was strong. More category 5s will come… It will be big changes in the future*. (Viniana Salabogi, 52 years, July 2017)
More landslides, altered river dynamics	*In the future, more landslides will happen because many people cut trees… also, decrease of the river level. He does not know if it will ever dry up… all the questions.* (Netani Salaba, 19 years, July 2017)
Increased population and development	*In the future there will be over-population, people will still be coming over and there will be so many houses built because of so many boys here. They have to build one boy one house. Of course, it will grow.* (Camari Tuimala, 56 years, July 2017) *In the next 20 years, I think our village will be like somewhere in Los Angeles. You'll start to see a big house, different lights. That's a good thing but I don't think I'll still like that day*. (Penisimani Rabenawa no. 2, 25 years, July 2017)
More land clearing for houses	*More houses will move to this area in the future. People might only move after their house is damaged. He thinks more bush here will be cleared in the future for people to build houses*. (Venieli Nawasala, 37 years, July 2017)
Attitudes	*Changes will happen in the near future… Our behaviour of each individual will also change…. For us individuals, our behaviour will change if we don't rely on god. If you do not rely on God everything will just fall apart. So, you have to pray a lot, you have to, because if not, our connections through families will be broken. The bible says that changes will be coming within families, within each individual which lives among you because that is what change is gonna bring there will be problems faced so people have to expect those things in the future and be ready for it.* (Ananaisa Namatua, 59 years, July 2017)

5.6.2 Future adaptive capacity

Future adaptive capacity concerns the degree to which the community can deal with the estimated future exposures (Ford and Smit, 2004). Participants identified a suite of actions that could be taken and these are described in Table 5.6.

Table 5.6 *Potential future adaptation actions*

Actor	Adaptation action	Description and purpose
Community members	Stop cutting trees and revegetate slopes	Remaining trees should be left intact and degraded hillslopes and riverbanks should be revegetated to stabilise soils and reduce risk of soil erosion and landslides
	Listen and take heed of warnings	Broadcasted warnings should be taken seriously and responded to accordingly to reduce damage and harm during severe weather events
	Housing relocation	Relocation of buildings away from the river to reduce the risk of flood-related damage
	"Wait and see"	Adoption of a 'wait and see' attitude results from limited or no access to future climate scenarios and insufficient information to proactively employ adaptation strategies
	Pray hard	Grounded in strong Christian beliefs, resorting to praying to God for protection was a documented adaptation strategy
Government / NGOs	Electricity provision	The proposed extension of power lines will deliver connection to the national electrical grid and eliminate operation and maintenance costs for the existing diesel generator
	Remote subsidies	Remote subsidies may assist people living in rural areas by offsetting transport costs to access markets, goods and services

	Improve access (roads, bridges)	Improved road access would increase the ability for people to access markets, goods and services especially in times following severe weather events where access is frequently disrupted
Community & Govt. / NGOs	Crop insurance	Crop insurance is the concept of farmers purchasing premiums to ease the burden of crop loss following natural hazards, pest/disease damage, etc.
	Workshops	Workshops would expose villagers to learning experiences to gain knowledge regarding disaster preparedness, potential climate change impacts, climate change-tolerant crops, etc.
	Adequate drainage systems	Adequate drainage could reduce the amount of underground flow and localised erosion. Underground flow from new flush toilets was a perceived cause of recent erosion

Many of the adaptation actions described in Table 5.6 relate to an individual's or the village's ability to access and utilise capital resources. These include economic, physical, natural, social, human and political capital.

Economic capital: accessing financial resources enables people to invest in alternative solutions if, and when, existing or past methods of practice fail. For example, families who farm sloped areas susceptible to landslides are hesitant to relocate due to the potential loss of income because of the increased among of work required to prepare new plots and likely decreased productivity. Without the financial security to suffer potential losses, people continue to cultivate the sloped land, and continue to put their assets and people's well-being at risk. Supporting the findings of Magee et al. (2016), lack of financial support has prevented people from rebuilding their homes in disaster-resilient standards despite their desire to improve standards. Limited access to finances was perceived to be a "*major thing affecting achieving goals*" regarding the implementation of adaptation strategies in Nawairuku (Group *talanoa* participant, August 2017). At present, the community often waits for a donor NGO to provide funds to implement action. "*When they come, it is positive what they bring to the village… I think money is the major cause of things not happening in the village*" (Group *talanoa* participant, August 2017).

Physical capital: ownership or access to vehicles, farming equipment and livestock could enhance the ability for individuals and households to adapt to change. Private vehicles are a very sought commodity for households but owning one is unimaginable for many people due to the costs involved to purchase, operate and maintain a vehicle. At the time of the research, two households owned carriers. These families can deliver agricultural goods to market and to alternative middlemen and negotiate higher sale prices. Owners of livestock, horses and bullocks, are advantaged by having access to localised transportation, and the ability to power manual farming equipment (ploughs and tillers). Farmers travel by horseback to access farms that are located up to 5 km away from the village up steep terrain. Bullock pairs are a highly desired asset and most commonly used for land preparation (pulling ploughs, tills and spike harrows) and for transportation of heavy construction items such as felled logs and other construction materials (corrugated iron sheets, timber slabs). Approximately 10 working bullock pairs were in use during the research period. Participants commented on the increased ease and speed of farming when bullocks are used.

Natural capital (lands, forests, water, biodiversity): the ability to draw upon and utilise land, water and biodiversity resources benefits the lives and livelihoods of villagers. Some participants have implemented strategies to increase their income of crops already grown in the village by continuing to grow specific crops in their respective off seasons. The position of Naiwairuku offers a geographical advantage as densely forested and high-altitude land and riverbanks offer moist soils that can be used to cultivate wet-season crops even through the dry season. While examples of strategic land use have been displayed, there are several constraining factors that limit the effectiveness of such strategies. The physical location of Nawairuku results in limited availability of arable land. Surrounding land is steep (greater than 30 degrees in some places) and available flat land, potential yields and subsequent incomes are restricted. Cultivating surrounding slopes increases susceptibility to landslides, hence increasing vulnerability to harm.

Social capital (networks and connectedness): the traditional Fijian way of life (*bula vakavanua*) benefits all people in times of stress as burdens are shared and individual pressures eased. The custom of *kerekere* in Fiji is when a relative or neighbour can request something that is needed and is willingly given with no expectation of repayment. This custom is currently practiced in Nawairuku and is frequently used when households run low on finances or household items (flour, oil) or when farming equipment is required (wheelbarrow, bullock pair, etc.). By sharing the burden of insufficiencies or financial stresses, no one individual is left to struggle alone. Instead, the community supports each other and assists each other in times of need, knowing the act is reciprocal in the future if circumstances change.

Human capital (do-it-yourself attitude): some people of Nawairuku have adopted a '*do it yourself*' attitude, partially due to the limited trust in governance systems and the physical isolation and distance from external sources of support. People have learnt that assistance from the government and NGOs takes a lot of time and negotiation, and can result in maladaptive initiatives being implemented, prompting people to take individual and community-level action. This self-sufficiency facilitates adaptation by encouraging community members to take initiative and lead with community-based actions rather than waiting for a helping hand.

> *We can't just sit down like this and wait for the government or the NGOs to come and do the work. We have to stand up and take action in order to prevent climate change*. (Group *talanoa* participant, August 2017)

While the above attitude resonates with some of the population, others continue to depend on external assistance without the initiative to implement strategies to deal with arising challenges. Further, some people expressed their reluctance to adapt, namely, abandoning their current location of residence to relocate away from flood-prone areas nearby the river. People have repeatedly sustained damage from floods by remaining in the same location due to wanting easy access to the river and potable water.

He still wants to build his house here even though it is in the red zone. He wants to stay here because of the access of water. Here he has the tap here and it is easy to get the water. That side they still don't have the water pipes coming up to them so it is very difficult. And they should have the flush toilets. Floods come not very frequently so the chance of having a flood is less, so he would rather just rebuild [in the same place]" (Jone Sokiveta, 51 years, August 2017)

Political capital: institutional weakness is a limiting factor of climate change adaptation in many developing countries and Fiji's limited institutional capacity inhibits the implementation of policies and regulations and was frequently identified as a constraining factor for effective adaptation. Among the participants and wider community there was a perceived disconnect between the village level and the Provincial Council and upper government administration level. Village-level requests that arise from village meetings must be submitted in written form to the Ra Provincial Council (PC) who then pass it on to relevant bodies. This process is slow, and often neglected causing grassroots issues to struggle their way to the top rung of the Fijian administration. The perceived negligence of the local Ra Provincial Council and the upper administration staff to assist with locally-relevant requests constrains implementation of local resolutions and adaptive measures.

*[The] big issue is that the PC is not doing their job. That really happens. PC officials can sit in council for years and years. They sit there, and start fooling us. When there's a sound, or when there's a smell. They just *sniff* or give their ear but nothing happens*. (Group *talanoa* participant)

Continuing from this, a challenge unique to geographically remote populations is the tendency for government and non-government representatives to carry out very short visits. This is likely due to the long travel times to and from the village from Suva or other urban centres. Typically, a government official will come to the village for a prearranged *talanoa* session at the community hall were all village residents can attend. Unfortunately, the short duration of government and non-government official visits means that there is limited opportunity for villagers to communicate their priorities; consequently, government and non-government decisions often fail to meet the expectations and needs of the village.

They are not doing what is according to the plan for what the community needs… NGOs and Governments think they are doing the right thing but they are not… They have to listen to us from our experience. [They need] to do the job properly rather than cause more problems. (Male participant, 54 years, July 2017)

In some instances, well-intentioned initiatives to improve infrastructure in the village have proven to be maladaptive. For example, despite villagers raising concerns about the potential of sewage leakage from tin septic tanks, drawing on their knowledge of what happened previously in the village, the NGO insisted that this was the best way forward for the village. The village leadership had two options, accept the septic tanks or not; they chose to accept. The septic tanks started to leak less than a year after their installation posing health risks to villagers and creating a new problem that the village now has to deal with.

5.7 Conclusion

The aim of this study was to document and describe how people in Nawairuku village are experiencing and adapting to climate change in the context of recent socio-economic changes. The findings suggest that an interior village experiences and responds to climatic stressors differently than a near urban village located in the coastal zone as described in existing literature. This is not surprising, given the differences in physical and human geographies, but it does draw attention to the importance of investigating climate change impacts, vulnerability and adaptation at the local scale and with people living outside the coastal zone. This investigation reveals the existence of strategic policy entry points to support adaptation in Nawairuku to current and expected future climate change, many which are rooted in access to capital resources.

The finding that climate change is being experienced in the context of multiple climatic and non-climatic stressors is consistent with the findings of McCubbin et al. (2015) in Tuvalu, Chandra and Gaganis in Fiji, Pearce et al. (2015b) and Lede (2018) in the Canadian Arctic, O'Brien et al. (2004) in India, and McDowell and Hess (2012) in Bolivia. This finding highlights the complexity of social-ecological systems and the need to consider the socio-economic and cultural factors, which influence how people experience and respond to climatic stressors. For example, carpentry workshops that share methods for building more resilient structures to cyclones are only effective if the necessary building materials are accessible. This however, is often not the case, and people in Nawairuku, despite having the knowledge of more resilient building techniques, are unable to operationalise this knowledge. This finding shows that adaptation to a climate stress, in this instance, more intense cyclonic winds, is rooted in having access to a capital resource. Enhancing access to capital resources, in this case building materials, represents a strategic policy entry point that improves building standards and makes buildings more resilient to current and expected future cyclones.

The changes in agricultural practices are mostly driven by people's desire to acquire more income to pay for rising living costs, and feed a growing population. Until the 1980s, people grew root crops, fruits and vegetables for subsistence and it was considered *tabu* (taboo) to sell root crops. This has since changed with most farmers engaging, to varying degrees, in commercial agriculture. Farmers have been able to increase yields and profits through the intensification of agriculture and the use agrochemicals, but not without consequences for the longer-term health of soils. Additionally, some older participants believe when root crops are sold, and a *tabu* has been committed, those farms will face difficult times. Effective management of the natural resource base that supports agriculture is vital to longer-term productivity. This finding is noteworthy because it shows that despite emerging climate stressors like changing seasonal patterns and extreme weather events, if people do not sustainability manage the soil, future agricultural productivity will be negatively impacted. Efforts are needed to make knowledge of how to sustainably manage agricultural production at rates that meet local needs, accessible to villagers. This means, for example, creating plain-language documents that

are translated into the local dialect, and are made available in hard-copy as most people do not have access to a computer or the Internet.

The finding that people in Nawairuku take initiative to prepare and respond to extreme weather events like recent cyclones and floods is noteworthy. People in Nawairuku have a do-it-yourself mentality and are motivated to take actions to sustain and improve their livelihoods regardless if they receive support from outside government or non-government sources. The community proved this ability in their prompt post-TC Winston clean-up efforts, cleaning the village compound and fixing the water distribution system much faster than other villages. A key factor in getting things done in the village is the presence of strong leaders who operate outside of the traditional village hierarchy. That said, this is also sometimes seen as a constraint to getting this done due conflict between those leaders who emerge naturally and those who lead through heredity. This initiative differs from what has been found in other Fijian villages, where people tend to wait for government or non-government assistance rather than taking actions to address a sustainability issue themselves (Pearce et al., 2018). People in Nawairuku are not short of motivation or initiative but they are often short of financial and material resources important for adaptation.

Some of the adaptive strategies being employed in Nawairuku are tangible whereas others are intangible and draw on non-empirical sources. The success of tangible actions such as planting fruit trees around houses and installing bracing on houses to help them withstand strong winds, can be both seen and measured. On the other hand, intangible actions such as praying to a higher power to protect oneself and the village from future harm is more difficult to measure. For example, demanding the flood waters to stop rising or praying for good weather have proven to be successful in the views of villagers. However, despite the efficacy of such intangible actions, religion and strong beliefs in God was found to be a barrier to some proactive adaptations. Some villagers depend on God's divinity to save them from the impacts of climate change rather than their own proactive efforts. This shows the need to understand local belief systems and work with them to combine both tangible and intangible actions, to create win-win scenarios, in which it is not important to attribute success to either strategy if it works.

As previous research has outlined, when discussing opportunities to support adaptation, it is important to understand the interconnectedness of socio-economic and environmental factors and recognise local culture and context. Only then is it feasible to support adaptation strategies that meet the needs of local people in a culturally appropriate manner. The findings of this research are intended to expand the current narrative of climate change impacts, vulnerability and adaptation in the PIR generally and in Fiji specifically to include the experiences of people living in the interior. Future work in Nawairuku and elsewhere in Fiji must attend to these important cultural and contextual factors if we are to better understand how best to support villages adapt to current and expected future climate change.

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Chapter 6: Preparing for, Experiencing, and Responding to Cyclones and Flooding in Nawairuku village, Ra, Fiji

Preparing for, Experiencing and Responding to Cyclones and Flooding in Nawairuku village, Ra, Fiji

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Abstract

Fiji is geographically exposed to a suite of natural hazards, including cyclones and floods. The media often characterises Fijians as passive victims of hazards when in fact they are often active players in mediating how hazards are experienced and responded to. We need to understand the role of human agency in disaster risk reduction in order to identify opportunities to assist communities prepare for hazard events. This paper analyses how people living in Nawairuku village in the interior of Ra Province, Fiji, prepare for, experience and respond to natural hazards through a case study of Tropical Cyclone Winston and a major flood event. The analysis of data collected through semi-structured interviews and focus groups with villagers reveals that: perceptions of risk influence the way people respond to warnings and prepare for disaster impacts; the level of preparation effects the amount of damage sustained; and past experiences with less severe events has made people less prepared for more severe events. Efforts to build resilience within the system are needed to lessen the impact of future hazard events.

Keywords: climate change, disaster risk reduction, natural disaster, adaptation, vulnerability, resilience

6.1 Introduction

The Pacific Islands region, including Fiji, is geographically exposed to a suite of natural hazards, including cyclones, floods, droughts, earthquakes, volcanic eruptions and tsunamis (Campbell, 2010). Natural hazards are defined here as atmospheric, hydrologic, geologic, and wildfire phenomena that, because of their location, severity, and frequency, have the potential to adversely affect humans, their structures, or their activities (Bender, 1991). In Fiji, hazard events like cyclones and floods disrupt societal functions and cause widespread human, material, economic and environmental losses (Nolet, 2016; O'Brien et al., 2010). In recent decades, climate change has exacerbated existing natural hazards and together with societal changes, has resulted in new risks to human livelihoods (Asian Development Bank and International Food Policy Research Institute, 2009). It is increasingly recognised that to better understand what natural hazards mean for people and communities requires knowledge of how people prepare for, experience and respond to hazard events,

including the role of socio-economic and environmental drivers (Thomalla et al., 2006; Das, 2009). This knowledge is particularly salient given the volume of national and international aid directed at hazard response in Fiji. An estimated AUD$76.7 million was received by Fiji by the Australian Government's Official Development Assistance program between 2016 and 2017. Most recently, Australia provided a total of $30 million for humanitarian assistance ($5 million for immediate relief, $10 million for early recovery, and $20 million for recovery and reconstruction) in response to Tropical Cyclone Winston (February 2016) (Australian Government DFAT, 2018).

This paper analyses how people living in Nawairuku village in the interior of Ra Province, Fiji, prepare for, experience and respond to natural hazards through a case study of Tropical Cyclone (TC) Winston and a major flood event. The study responds to calls from foreign aid and government workers for a better understanding of the local context for hazard events so that they can direct their money and efforts in ways that will best support communities. The findings of this paper are part of a larger climate change adaptation study in the village. Data were collected between June and August 2017 in Nawairuku by university researchers and local research partners. The fieldwork involved semi-structured interviews (n=30), focus groups (n=2) and participant observation. Semi-structured interviews were conducted with a cross-section of the adult population, achieved through snowball sampling techniques. Interviews were conducted in English or the Ra dialect, chosen by the participant. The research for this paper was guided by the following questions: (1) how does perception of impacts influence how people prepare? (2) how does level of preparation influence how people are impacted by disasters? and (3) how does experience with past disasters inform future responses to disaster? While this research identifies entry points to support response and recovery efforts, the ultimate goal is to support proactive initiatives that reduce harm and losses.

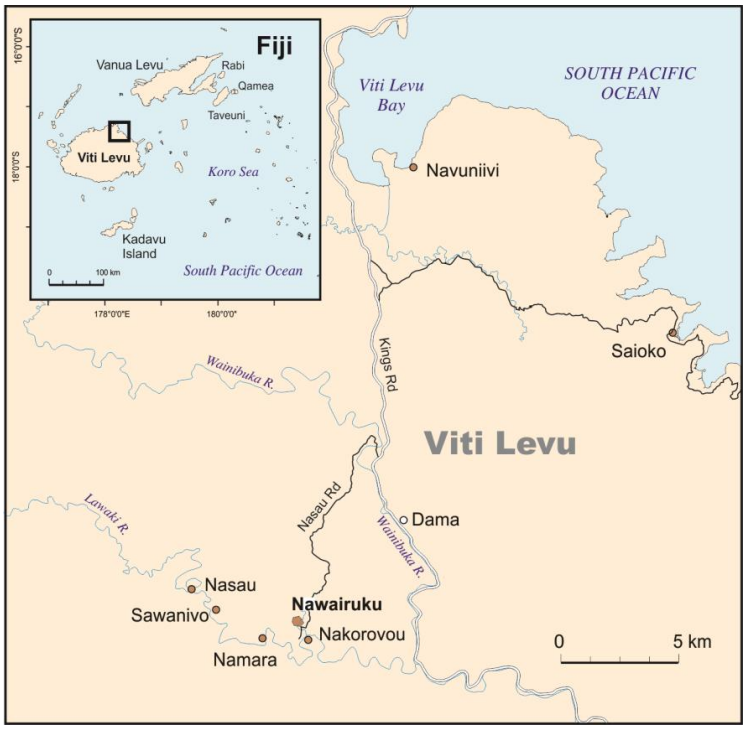
6.2 Case Study: Nawairuku, Ra Province, Fiji

The Fiji Islands lay in the Southwest Pacific Ocean between 177°E-178°W and 16°S-20°S. The country comprises 332 islands with a total landmass of 18,333 km^2 and a population of 884,887 (Australian Bureau of Meteorology and CSIRO, 2011; Fiji Bureau of Statistics, 2018). The two largest islands, Viti Levu and Vanua Levu make up 87% of Fiji's total land mass and are mountainous of volcanic origin. Other islands are smaller volcanic islands, low-lying atolls and elevated reefs. Ra Province is positioned in the north-east quadrant of Viti Levu and is known as one of Fiji's "salad bowls", abundant in root crops and *yaqona* (kava plant) (Davetta, 2017). Ra province covers an area of 1,340 km^2 and has two major towns (Rakiraki and Vaileka) and 89 villages of which Nawairuku is one (Davetta, 2017). Nawairuku village is located in the rural interior of Ra Province at an elevation of 51 metres (17°38'15.52"S, 178°12'51.66"E) (Figure 6.1). Nawairuku has a population of approximately 320 (100% *iTaukei*[1]) residing in approximately 60 households (personal observation

[1] iTaukei = Indigenous Fijian people

2017). The village is situated within mountainous terrain typical of the Fijian highlands, surrounded by dense tropical forests and steep slopes. All families rely on subsistence farming for subsistence and income. The geographical location of the village contributes to its inherent exposure to natural hazards. Nawairuku is situated in a riverine valley between Tavunikoko and Namolaca mountain ranges surrounded by steep forested and cultivated hills. Villagers maintain that this location means it is possible to receive winds from all four cardinal directions. The village is adjacent an upper-catchment tributary of the Lawaki River which, in turn, is a tributary of the Wainibuka and Rewa Rivers, all part of the Rewa Basin. These geophysical elements pose a risk to the community in times of severe weather.

Figure 6.1 *Location of Nawairuku village in Ra Province, Fiji*



6.3 Tropical Cyclone Winston and extreme flooding

Tropical Cyclone (TC) Winston was the first-ever Category 5 cyclone to make landfall in Fiji and the South Pacific Basin in recorded history (NASA, 2016). It crossed the north-east coast of Viti Levu and tracked westward leaving a trail of destruction, some 131,000 people homeless, 44 lives lost, and an estimated AUD$2.5 billion in damage to crops, livestock and infrastructure (Mangubhai, 2016; Armbruster, 2017; Aquino et al., 2018). The Fiji Government estimates 62% of the population (around 540,000 people) were directly affected by TC Winston (Miyaji et al., 2017). TC Winston passed directly over Nawairuku at approximately 9pm on the 20th of February 2016 and severely affected local agriculture, physical infrastructure, and human health and well-being with ongoing effects being felt some two years later. As TC Winston was the most intense cyclone that has affected Fiji in recorded history, older participants (>50 years) compared the vast difference in severity and

inflicted damage caused by Winston compared to previous cyclones they had lived through in the past (Cyclone Bebe in 1972 and Cyclone Kina in 1992, both Category 3). Unbeknownst to the people of Nawairuku, TC Winston was far greater in strength than cyclones they had experienced in the past yet people were expecting a similar experience of Cyclone Bebe and Cyclone Kina. These observations are consistent with instrumental weather data that quantifiably corroborate the participant narratives. TC Winston maintained substantially stronger sustained wind speeds and resulted in more deaths and damages (Table 6.1) (Krishna, 1981; Prasad, 1993).

> *No, Winston is the biggest hurricane I ever come across. In the past, you know, once the hurricane comes, we don't bother about clearing the place, to move the iron, once it comes. But Winston, no! Surprised us. Bigger than what we expect*. (Ilaitia Netaba no. 1, 75 years, July 2017)

Table 6.1 *Characteristics of Cyclones Bebe, Kina and Winston*

Cyclone	Date	Category	10-minute sustained wind speed (km/hr)	1-minute sustained wind speed (km/hr)	No. of fatalities	Estimated damages (USD)
Bebe	Oct 1972	3	155	20	24	$20million
Kina	Dec 1992	3	150	220	26	$110million
Winston	Feb 2016	5	280	285	44	$1.4billion

Approximately 10 months after TC Winston, Nawairuku endured a record-breaking flood associated with a slow-moving tropical depression (Tropical Depression 04, or TD04F), the first of the 2017/18 cyclone season (ReliefWeb, 2016). Floodwaters rose rapidly on 17 December 2016 at a time when the community was rebuilding homes and re-establishing farmland causing widespread damage throughout the village, again, to infrastructure, accessibility and cultivated land. Floodwaters forced businesses in Rakiraki town to close, and Nausori town downstream was threatened by the flooded Rewa River which peaked at more than four metres (Pacific Beat, 2016). Inadequate instrumental weather data limits the ability to know the exact amount of rain that was received in Nawairuku and the upper catchment to cause localised flooding. However, Nausori Airport is the closest reliable weather station and recorded 226 millimetres of rain in 24 hours on the 17th of December 2016 (ReliefWeb, 2016).

The flood event associated with TD04F was reported by people in Nawairuku to be bigger and more severe than anyone could remember. In particular, the older participants noted previous floods had never been this widespread across the village. Although some residents had taken precautions to avoid infrastructural damage from floods by building raised houses on wooden stilts, the floodwaters of this event rose far above previous flood levels and was close to breaching the raised floor level.

> *The river, when there is a flood, the water will just flow according to the river bank. But just recently the flood that just happened, that's the first flood she's ever come through that was not like others. The water reached up to her house, the double story home – it reached it, the whole ground, nearly the whole village got flooded. If the rain came in that night the whole village would have flooded.* (Ekari Bainivalu, 67 years, July 2017)

6.4 Preparing for TC Winston and Flooding

The United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA, 2013) defines disaster preparedness as the process of ensuring an entity can continue to sustain its essential functions without being overwhelmed by the events of a natural disaster. To ensure this, the entity must: comply with preventative measures; be in a state of readiness to contain the effects of an event to minimise loss of life, injury and damage to assets (infrastructure and agriculture); and be able to provide rescue, relief and rehabilitation in the aftermath of the disaster. The elements of this definition were not fulfilled by the community in Nawairuku ahead of the events of TC Winston and recent major flood events, hence they were overwhelmed by the events discussed here.

It is widely acknowledged that people's perception of environmental risk determines both the nature and degree of their response (Adams 1995). Peoples' perception of the approaching TC Winston and floods was that the events would be no different to cyclones and floods experienced in the past. This belief resulted in insufficient action being taken and little effort given to secure infrastructure and prepare emergency supplies (food, water). Having heard radio warnings for cyclones and other extreme weather events in the past and not being directly affected by them also dissuaded people to prepare.

> *People thought it would be just a small one. They really had the shock of their life. Most of us were unprepared. Even us, not well prepared. We just did some small hammering. Put some iron across the windows and that was it. Most of the people were not prepared for Winston, just relaxing*. (Kalara Veramu, 40 years, August 2017)

This under-exaggerated perception, coupled with the inadequate duration of warning period, limited the implementation of tangible preparations to minimise damage. Warnings were received by radio and social media two to three days before the impact of TC Winston, yet there was a lack of preparation. The warnings ahead of TC Winston were confusing; the initial warning was issued by Fiji Meteorological Service on the 14th February and was gradually expanded through 15th February, but as TC Winston tracked away from Fiji the warning was cancelled on 16th February (Fiji Meteorological Service, 2016a; 2016b). As the storm doubled back and neared Fiji, warnings were resumed on 18th February and remained until the system passed and weakened in strength before dissipating while tracking south-east (Fiji Meteorological Service, 2016c). The consensus of the participants and wider community was that the community was not enough prepared for the force of TC Winston. Participants recalled the lack of time between receiving warnings and the eye wall passing over the village as being the reason they were ill-prepared.

> *People in Nawairuku were not prepared for it because it came suddenly, they were not prepared for it. Warnings may not mean it is actually coming. The thing is, sometimes they say the wind is coming this way and it won't be affecting these areas but we don't know because it changes its ways and changes its path. There were warnings but people don't consider that it might come this way or effects of it might affect us*. (Apenisa Waqawai, 60 years, July 2017)

Similar narratives tell the story that preparations were not made to avoid damage leading up to the major flood in December 2016. No official warnings were received in Nawairuku and people responded only to the visibly rising water level in the river. Many people used hope and prayers as measures to stop floodwaters rising so their houses would avoid inundation. Others moved some belongings to higher grounds ahead of time but many people waited until the floodwaters were inevitably inundating their house and belongings when it was too late to avoid damage.

> *I came up again and said to my mother, "oh!" We have to put our things higher because I don't know if the water will come here. After two minutes I said that, the water was coming. Flash flood! Very fast! No time to move things*. (Waisea Somisucu, 48 years, July 2017)

Despite having little time to act ahead of the cyclone and flood, some preparation methods were employed in Nawairuku to protect infrastructure, livestock, food security, and ultimately human welfare during severe weather events (Table 6.2). These methods were implemented to varying extents among households and had had varying degrees of effectiveness and extent of implementation.

Table 6.2 *Different methods of preparation for natural hazards*

Purpose	***Method***
Protect physical infrastructure	• Dismantle *bolabolas* (temporary structures made of bamboo poles and tin roof) • Cover windows with iron sheets • Secure roofs with iron rods or heavy stones • Hang gallon water containers to secure roof bracing • Cut fruit trees nearby houses
Protect personal belongings	• Move household belongings to higher ground
Secure livestock	• Untether livestock to instinctively seek adequate shelter
Increase food security	• Cut cassava stems short to avoid wind damage • Keep an emergency stockpile of non-perishable foods • Plant *kumala* in October/November so yield is ready for harvest in cyclone season
Human well-being	• Have phone with you to keep updated by warnings • Share warning updates with others • Plan evacuation route and emergency shelter

6.5 Experiencing TC Winston and Flooding

Many participants recalled the experience of TC Winston with thoughtfulness and sombreness. One man compared the force of the wind blowing on his house to the feeling of driving in a truck on an unsealed road – bumping and shaking. Another man describes the moments of seeking protection from winds and rain under his bed after his roof was blown off before running to a nearby house for shelter.

> *When Winston comes, this house just like we riding the vehicles that are driving on the gravel. I told her, she [his wife] was making the mat here, I told her. Hey, prepare yourself, otherwise the whole post under the house will take away. Prepare yourself when it is coming up, jump outside, save your life. [Were you worried?] Yeah, yeah, yeah! Because the hurricane, this house, just*

like we drive by carrier on the gravel. I told her but she forgot the hurricane, she just lay making the mat! Hey, what you doing? Yeah, I know, hurricane is going. I told her. be prepared otherwise the house will be taken, jump out! (Epeli Raisevu, 58 years, July 2017)

One lady tells the story of opening the front door to seek more secure shelter and being blown by the force of the wind across the rooms in her house before knocking into her husband and slamming them into a wall opposite the doorway.

When they opened up the house they didn't know that a strong wind would come in. She was at the doorway when a wind came and blew her into the house right up there and then it blew him too. That winds took out all the louvres in the house. She didn't expect him to be blown and then he sat on her. She wasn't expecting that. (Camari Tuimala, 56 years, July 2017)

After days of heavy rain associated with the Tropical Depression 04 (TD04F), the river broke its banks and flooded areas adjacent the river. The force of water from the Lawaki River pushed up the tributary and up village drainage systems, inundating areas far away from the river. The floodwaters remained at peak level for approximately 10 minutes before receding, leaving a punishing mess requiring substantial clean-up efforts. The experience of the flood was less intense that that of TC Winston but, nevertheless, incurred serious damage to infrastructure and agricultural assets and affected human health and well-being.

6.5.1 Impacts

TC Winston and the December 2016 flood had significant impacts on agricultural systems, physical infrastructure, and human health and well-being in Nawairuku. The Government of Fiji's Post-Disaster Needs Assessment (2016) explores damage and losses by sector highlighting social impacts of each, providing a comprehensive overview of impacts and highlighting recovery and resilience needs.

6.5.1.1 Impacts on agriculture

In 2014 the agricultural sector (crops, sugar cane, livestock, fisheries and forestry) made up 9.4 percent of Fiji's GDP, of which crops and livestock constitute 72 percent (Government of Fiji, 2016). The crops subsector was the most affected by TC Winston with permanent crops (kava and coconut), and annual crops (cassava and *dalo*) suffering the most losses. Total crop losses amounted to FJD$207.9 million (Government of Fiji, 2016).

A significant amount of cropland in Nawairuku sustained devastating damage during TC Winston and flood events in December 2016. Winds up to 300km/hr, heavy rainfall and flash flooding associated with TC Winston caused physical damage to agricultural land, including landslides and tuber waterlogging, which destroyed most crops (NASA, 2016). Participants reported losing whole harvests of *dalo*, cassava, *vudi* (plantain), and *uvi* (yam), and the expected income they would have earned by selling the produce. Similarly, during the December 2016 flood, some villagers lost plots of land that were simply washed away by floodwaters. The fertile, moist soils near the river are an inviting location to plant short-term crops and *dalo*; however, plots located here and near village drain

systems are especially sensitive to flooding. Slope stability and landslides are an issue of concern for villagers. The first reported landslide occurred in 2004 and there is no memory of landslides in the area prior to that event. In recent years, intensive forest clearing has occurred on the slopes surrounding the village site for the cultivation of root crops, reducing the stability of the slopes. During TC Winston, landslides were triggered by heavy rainfall, which saturated the relatively loose soils and prompted weakness in the stability. Agricultural plots were completely lost following the landslide events and fertile soil was stripped from the hillside. Loss of produce results in financial hardships and livelihood stresses.

> *Yes, many crops damaged in Winston. One year I didn't get anything from the crops, one year no income. Just stay and try to rebuild to restart to earn the living. Replant everything and start planting again because Winston take it away. Some dalo, rourou, still in the village*. (Penisimani no. 2 Rabenawa, 25 years, July 2017)

> *Normally they used to plant the vegetables beside the river. When the big floods come they will wash away the vegetables. They have their source of income from those vegetables. When the flood came they washed away.* (Selai Lewayava, 35 years, July 2017)

6.5.1.2 Impacts on physical infrastructure

Across the South Pacific region, tropical cyclones and increased rainfall and associated flooding have resulted in extensive infrastructural and agricultural damage and losses (Fletcher et al., 2013). TC Winston imposed an estimated AUD$2.5 billion value of damage and losses across the nation with FJD$777.4 million and FJD$542 million associated with housing and agriculture, respectively (Government of Fiji, 2016). TC Winston destroyed 7.5 percent of Fiji's total housing stock and caused major damage to an additional 6.3 percent (Government of Fiji, 2016). Extensive damage was sustained in hundreds of villages in the direct path of TC Winston and the experiences in Nawairuku are reflective of many other villages in Fiji.

Participants described the impact the cyclone had on village infrastructure including houses, community dwellings, water and power distribution systems, and roads and bridges (Figure 6.2). One participant shared how his "*iron roof was torn away like paper*" (Epeli Raisevu, 58 years, July 2017). A total of sixty-two houses sustained damage significant enough to be eligible for government-provided funds for rebuilding. The Fijian Government offered vouchers of varying values to purchase construction materials. Table 6.3 presents the breakdown of the three categories of damage and the respective amount of funding received. This dataset was obtained from kept records from the *turaga-ni-koro* (village headman) who recorded the damage to deliver to authorities for recovery compensation. Despite the staggering number of households who received financial assistance, some households did not receive any funds and were required to self-fund the repairs, adding further financial burdens. Heavy rainfall associated with the cyclone triggered landslides on the cultivated slops surrounding the village causing damage to school infrastructure which was being rebuilt during the study period.

Table 6.3 *House damage by TC Winston and recovery funds received*

Category of damage	***Number of households***	***Recovery funds allocated ($FJD)***	***Total ($FJD)***
"**Fully destroyed"**	42	7000	294,000
"**Full roof damage"**	9	3000	27,000
"**Partial roof damage"**	11	1500	16,500
Total	62		337,500 (≈ AUD $215,000)

Figure 6.2 *Infrastructural damage in Nawairuku following TC Winston on 21 February 2016 (left) and in July 2017 (right)*

Source: Left: Luke Vuli, Nawairuku Turaga-ni-koro (2016), Right: R. Currenti (2017)

Many residents were in the final stages of rebuilding their houses when the floodwaters ravaged the village. While the floodwaters incurred no structural damage to houses, the clean-up effort was phenomenal. Layers of mud up to two feet thick carpeted the inside of houses, smothering whitegoods, kitchen tools, woven mats, bedding, clothes, and other household belongings. Road access is regularly cut to the village following heavy rainfall events as was the case following this flood event. There is one unsealed road (Nasau Road) that connects the village to Fiji's "ring road", Kings Road. If the bridge on Nasau Road is cut, the alternative route to access Rakiraki town (markets, services) is an additional three hours and costs more for villagers to use. Disrupted access impacts the ability for people of Nawairuku and other surrounding villages to access markets to buy and sell produce, inhibiting access to income. The force of the river damaged the bridge on Nasau Road beyond use and repairs took some 10 months.

> *When there is heavy rain and flood, that part of the bridge sometimes washes out. The flood that came again took half of the new one out… So, when that was washed out you come up another way. You have to cross the big river again. It is very difficult without the truck access. Plus, there is another way to come from another road to the village but it is very expensive because it is very far. You have to go all the way and come up that way. You have to go further up.* (Maria Moce, 28 years, July 2017)

Figure 6.3 *Floodwaters in Nawairuku village on 17 December 2016*

Source: Luke Vuli, Nawairuku Turaga-ni-koro

6.5.1.3 Impacts on human health and well-being

TC Winston resulted in FJD$13.9 worth of damage to the health sector in Fiji (Government of Fiji, 2016). A total of 485,030 people were affected due to the loss of their source of livelihood. Nationally, damage to wastewater management and sanitation facilities (toilets, household septic tanks) affected approximately 20,500 households (Government of Fiji, 2016). Power outages and physical damage to distribution systems affected access to clean water and the lack of access to clean water and sanitation posed health threats, particularly to girls and women.

People's physical health and well-being in Nawairuku were affected by TC Winston and flooding. Following Winston, one woman fell sick and was bedridden for a week with boils rising on her skin due to unhygienic conditions, constantly being wet from cleaning, poor nutritional intake, and lack of clean drinking water. She believed the main reason people got sick was because of the damaged pipes and inability to access clean drinking water. She further adds the clean water in the school borehole and the hundreds of fallen coconuts were a blessing for Nawairuku residents, providing necessary nutrients in lieu of unavailable nutritional foods. Other than exhaustion, people only suffered minor injuries sustained from roofing iron. There were several deaths in nearby villages.

> *Some just died in their homes even around here. Just close to Waimicia [a nearby village], one nursing mum down there. Because when the cyclone came they wanted to run it was just no time to run, one iron came flying and just cut her stomach*. (Kalara Veramu, 40 years, August 2017)

There was a shortage in fresh and non-perishable food supplies following TC Winston. Government-supplied rations were delivered by helicopter a month after TC Winston supplying flour, rice, sugar, cooking oil, canned food. Households depended on each other to share food supplies they had on hand. A schoolteacher recalled some children from Nawairuku and two other nearby villages facing food shortages and bringing no lunch for school or not attending school due to having nothing for lunch.

After a month government help came; the helicopter came with rations. They were just eating the left-over crop from Winston, crops that were not that damaged. They were using those things… If anyone comes over to your house to borrow sugar you should help that person out and give some sugar to them. The only important thing is for the shelter and the water. That is the most important thing for us to rely on [each other]. So, whatever help you can give, you give. (Camari Tuimala, 56 years, July 2017)

A female participant recalled her psychological struggle to comprehend and deal with the onset of another disaster threatening to damage her house after recovering from TC Winston. One elderly man suffered a stroke the day after the flood upon visiting his house and seeing the intense damage throughout. He sadly passed away in April 2016, two months after his first stroke. His daughter explains how it happened.

Kini just got all the boys to take all the stuff up. The clothes, like that, Jo's suitcase. Some other things. I don't want to go and take anything up. Like I'm growling or what? I was thinking of the cleaning up, it's very hard. Only Kini and the boys take the things, I don't want to, I just sit here and look at them. Big job, big job. (Viniana Salabogi, 52 years, July 2017)

He just came, came from that door, the one that you entered I think he just saw everything all over the place and he lied straight down. He came with Simeli, and they took him out from here to take him to their house, uncle Kini's house. That's where they start, one side, something like a stroke, all the left side of his body gets like shocked. That's when his sickness started. He just goes down slowly and lied down. He was limping in April. They said it was the first stage of a stroke. (Female participant, 30 years, July 2017)

6.6 Responding to TC Winston and Flooding

Post-disaster recovery efforts were longwinded and required internal and external support and effort. The recovery efforts post-Winston commenced the following morning and were continuing at the time of the research, eighteen months after the event. Despite that day falling on a Sunday, the Holy day and day of rest, villagers worked with power tools and trusted God would offer forgiveness. Recovery efforts began with a church service followed by months of rebuilding houses and re-establishing farmland. One participant shared an emotive account of the first day of the recovery. The translation is a combination of his words and the translated version from the local research assistant.

In the morning, he walked around the village and to the school. I nearly cry on that Sunday. All the coconuts fell. He felt so sorry for the village, the way it looks and how it turned out after the cyclone had gone. For example, the houses blown out. The tin was everywhere… especially the leaves from all the plants and trees. The first thing, on the Sunday we go to church. Kini called all the people in the village, we go and sit at the community hall and we have to talk about what's happening. On that Sunday, we clean all the rubbish up, the tin, all the … using a chainsaw… Only on that Sunday we use the chainsaw – only that Sunday, normally on Sunday you go to church and you don't hold a knife or chainsaw, you do no work. On that Sunday, they did work. God will forgive, to help each other. So, they cleaned everything up. Everyone helped with that. (Savenaca Naborisi, 56 years, July 2017)

External forms of assistance were provided by CARE Australia (water, sanitation and hygiene (WASH) kits and shelter kits), Australian Defence Force (food rations dropped by helicopters), and the People's Republic of China (temporary housing tents). As part of Fiji's coordinated effort to

rebuild from TC Winston, the *Help for Homes* initiative was designed to give affected households the necessary resources to rebuild their damaged homes to be more resilient to future severe weather events (Fiji Ministry of Communications, 2016). 62 households that sustained structural damage to their homes during TC Winston applied for and were issued electronic cards that can be used at selected hardware retailers to purchase materials to rebuild. The amount of funding was based on the extent of damage to respective houses (Table 6.3).

> *They got help from the Government to buy the materials to rebuild. It took months for the materials to arrive. They were given tarpaulins and the PR China tent outside to live in. They erected the tent in front of the house but the rains that came after the cyclone flooded the area so they had to move again. After the cyclone, it rained for about a month.* (Male participant, 40 years, July 2017)

It is understood that because of lack of preparation for TC Winston and the consequential sustained damage, the community is more likely to prepare for future cyclones in response to warnings. It was noted that several weeks after TC Winston, a warning was issued for another cyclone and villagers were far more responsive than previously.

> *It was funny because after how many weeks another warning came and the people were just running around and hammering their house, preparing for the cyclone and even they went to the evacuation centres and then the wind came slowly, so I am sure… I think they learned the lesson. I think next time the warning comes they will be better prepared. When people prepare, there is less damages. People could more properly secure their house and cut down trees beside their homes, or go to evacuation centres*. (Kalara Veramu, 40 years, August 2017)

6.7 Discussion

The finding that there was a breakdown in communication of disaster warnings shows there is room for improvement on the disaster communication front. It is vital that accurate and trusted weather information is communicated in a timely manner to ensure people take it seriously and act accordingly. Preparation is key to surviving a disaster and minimising damage, and adequate and accurate information is essential to cue preparation. "*Even if it doesn't come, you should be prepared"* was an attitude adopted by villagers after living through and learning from the mistake of being underprepared for TC Winston (Epeli Raisevu, 58 years, July 2017). This finding supports Ellis et al.'s notion that "*experience is a central factor in motivation, and the more recent the experience the better*" (2004, p. 42). The fresh memory of the extensive damage inflicted by TC Winston and the flood has encouraged people to think proactively and implement damage mitigation measures.

While there was no loss of life through direct impacts of the discussed natural disasters, massive infrastructural losses offer opportunities for implementation of long-term, sustainable adaptation options. The traditional one-roomed, thatched roof, earth floor *bure* proved its ability to withstand the elements of extreme weather events such as high velocity winds and heavy rainfall (Fujieda and Kobayashi, 2013). The move towards Western housing styles saw the replacement of traditional *bures* with contemporary houses constructed from newly introduced materials (iron sheet

roofing and walls, with wooden frame) in the latter half of the 20th century (Fujieda and Kobayashi, 2013). This transition saw the loss of *bures* and with it, the comfortable and climate-suitable designs.

The finding that rebuilding efforts resulted in the reconstruction of identical dwellings illustrated that people in Nawairuku are employing short-term coping strategies rather than adopting longer-term, sustainable adaptation solutions. While some people are incorporating more bracing in the designs of the new houses, the typical tin walled, tin roofed with pine bracing dwellings are still vulnerable to cyclonic winds. Lack of essential resources (knowledge, expertise, building codes, financial capital) confines people to building what they know, that is, the typical contemporary house. Supporting the findings of Magee et al. (2016), lack of financial support has prevented people from rebuilding their home in disaster-resilient standards. If another high category cyclone hits Nawairuku, which is likely under current projections (Hartmann et al., 2013; Nurse et al., 2014), the community will be faced with the same issues and architectural inadequacies will again threaten human lives. Building designs must be climate-proofed for longevity and confinements overcome to promote resilient housing standards (Miyaji et al., 2017).

In Nawairuku, generations of exposure to natural hazards should provide the population with knowledge and a platform for effective decision-making. Social learning is indicated through changes in the capacity to act arising through experience and can be the difference between important experiences being overlooked and forgotten or being translated to enhance capacity to deal with future uncertainties (Pelling, 2010). While knowledge has been passed from older people to younger people relating to disaster preparedness and response, the differences in cyclone intensity constrained the effectiveness of actions. For instance, the previous two cyclones that directly impacted Nawairuku (TC Bebe and TC Kina) were both category 3 systems but TC Winston was classified as a category 5 system. Ahead of TC Winston, it was not apparent to the residents of Nawairuku that this cyclone would be any different from the ones they had experienced in the past. Therefore, past experiences dealing with extreme weather cannot always be used as an indicator of what is to come. Preparations for future disasters should consider past experiences but also be robust enough to account for unexpected changes. Where experiences with natural hazards are considered a learning tool and lessons are carried forward, communities can implement actions to better their well-being, income, food security and decrease vulnerability and potential harm (Armitage et al., 2009). Lessons learnt from disaster experiences should be translated into practical changes in perceptions, preparations and responses to enhance future adaptive capacity.

6.8 Conclusion

The source of disasters is rooted in the relationship between people and their environments (O'Brien et al., 2010). Complementing the impacts of weather events, rapid population growth, rising living costs, agricultural commercialisation, introduction of agrochemicals, shifting seasonal patterns and westernisation are influencing the way people live and relate with the environment. The aim of

this paper was to analyse how people living in a remote, interior village in Fiji prepare for, experience and respond to natural hazards. The experiences from Nawairuku illustrate a number of things. First, perceptions of risk influence the way people respond to warnings and prepare for disaster impacts. The under exaggerated perception of TC Winston's force resulted in extensive damage to local agricultural systems, infrastructure, and health and well-being. Second, level of preparation effects the amount of damage sustained by disasters. Preparation on a number of timescales is vital to ensure the best chances for survival and reduced harm. Finally, while experience with past disasters adds a level of resilience to the community, the familiarity with less-severe events adds risk as the likelihood of more severe disasters rises. Locally relevant long-term, proactive efforts are needed to ensure community resilience to future natural disasters.

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Chapter 7: Conclusion

This research examined how people living in Nawairuku village are experiencing and responding to climate change. To date most climate change impacts, vulnerability, and adaptation research in the Pacific Islands region has focused on measuring biophysical impacts related to sea level rise with villages located in the coastal zone with less known about the experiences of people living in the interior. This research responded to this knowledge gap, and examines vulnerability to climate change in the context of multiple stressors with people living in a geographically remote village located in the interior of Viti Levu, Fiji. The aim was achieved through three objectives: (1) document the conditions that currently affect the livelihoods of people living in Nawairuku village; (2) characterise the adaptive strategies employed to manage and cope with these conditions; and (3) describe internal and external factors that aid or constrain current and future adaptation efforts. This chapter summarises the key findings; highlights how they inform the broader scholarship on climate change impacts, vulnerability and adaptation; describes opportunities to support adaptation in Nawairuku; and discusses opportunities for future research.

7.1 Summary of key findings

1. Climate change is being experienced in the context of multiple climatic and non-climatic stressors.

This finding is consistent with the findings of McCubbin et al. (2015) in Tuvalu, Chandra and Gaganis in Fiji, Pearce et al. (2015b) and Lede (2018) in the Canadian Arctic, O'Brien et al. (2004) in India, and McDowell and Hess (2012) in Bolivia. This finding highlights the complexity of social-ecological systems and the need to consider the socio-economic and cultural factors, which influence how people experience and respond to climatic stressors. For example, carpentry workshops that share methods for building more resilient structures to cyclones are only effective if the necessary building materials are accessible. This however, is often not the case, and people in Nawairuku, despite having the knowledge of more resilient building techniques, are unable to operationalise this knowledge. This finding shows that adaptation to a climate stress, in this instance, more intense cyclonic winds, is rooted in having access to a capital resource. Enhancing access to capital resources, in this case building materials, represents a strategic policy entry point that improves building standards and makes buildings more resilient to current and expected future cyclones.

2. Changes in agricultural practices are mostly driven by people's desire to acquire more income to pay for rising living costs, and feed a growing population.

Until the 1980s, people grew root crops, fruits and vegetables for subsistence and it was considered *tabu* (taboo) to sell root crops. This has since changed with most farmers engaging, to varying degrees, in commercial agriculture. Farmers have been able to increase yields and profits

through the intensification of agriculture and the use agrochemicals, but not without consequences for the longer-term health of soils. Additionally, some older participants believe when root crops are sold, and a *tabu* has been committed, those farms will face difficult times. Effective management of the natural resource base that supports agriculture is vital to longer-term productivity. This finding is noteworthy because it shows that despite emerging climate stressors like changing seasonal patterns and extreme weather events, if people do not sustainability manage the soil, future agricultural productivity will be negatively impacted. Efforts are needed to make knowledge of how to sustainably manage agricultural production at rates that meet local needs, accessible to villagers. This means, for example, creating plain-language documents that are translated into the local dialect, and are made available in hard-copy as most people do not have access to a computer or the Internet.

3. People in Nawairuku have a 'do-it-yourself' mentality.

The finding that people in Nawairuku take initiative to prepare and respond to extreme weather events like recent cyclones and floods is noteworthy. People in Nawairuku have a do-it-yourself mentality and are motivated to take actions to sustain and improve their livelihoods regardless if they receive support from outside government or non-government sources. The community proved this ability in their prompt post-TC Winston clean-up efforts, cleaning the village compound and fixing the water distribution system much faster than other villages. A key factor in getting things done in the village is the presence of strong leaders who operate outside of the traditional village hierarchy. That said, this is also sometimes seen as a constraint to getting this done due conflict between those leaders who emerge naturally and those who lead through heredity. This initiative differs from what has been found in other Fijian villages, where people tend to wait for government or non-government assistance rather than taking actions to address a sustainability issue themselves (Pearce et al. 2017). People in Nawairuku are not short of motivation or initiative but they are often short of financial and material resources important for adaptation.

4. Some of the adaptive strategies being employed in Nawairuku are tangible whereas others are intangible and draw on non-empirical sources.

The success of tangible actions such as planting fruit trees around houses and installing bracing on houses to help them withstand strong winds, can be both seen and measured. On the other hand, intangible actions such as praying to a higher power to protect oneself and the village from future harm is more difficult to measure. For example, demanding the flood waters to stop rising or praying for good weather have proven to be successful in the views of villagers. However, despite the efficacy of such intangible actions, religion and strong beliefs in God was found to be a barrier to some proactive adaptations. Some villagers depend on God's divinity to save them from the impacts of climate change rather than their own proactive efforts. This shows the need to understand local

belief systems and work with them to combine both tangible and intangible actions, to create win-win scenarios, in which it is not important to attribute success to either strategy if it works.

5. Efforts to support adaptation need to consider local context, knowledge, experiences and priorities.

As previous research has outlined, when discussing opportunities to support adaptation, it is important to understand the interconnectedness of socio-economic and environmental factors and recognise local culture and context. Community-scale adaptation research should involve local people and their knowledge in all stages of project development and implementation and understand that one size does not fit all (McNamara 2013; Buggy and McNamara 2016). For example, when external parties want to help the village, they need to first work with village representatives to fully understand the desires and needs of people. Only then is it feasible to support adaptation strategies that meet the needs of local people in a culturally appropriate manner. For example, while the village is usually very willing to accept external assistance, it is the duty of external parties to take the necessary time to ensure that their efforts align with village desires. This was evident in the example of the construction of tin septic tanks by an NGO even after villagers raised concern about the integrity of the tanks. The villager's concerns came to fruition and the tanks leaked, which resulted in additional expenses including the NGO returning to repair the tanks.

7.2 Scholarly contributions

Taken together, the findings of this research expand the current narrative of climate change impacts, vulnerability and adaptation in the Pacific Islands region generally and in Fiji specifically to include the experiences of people living in the interior. This expands the current scholarly understanding from a narrow focus on sea level rise and implications for people living in the coastal zone to include the lived experiences of people living in an interior village. The findings of the research support and build upon existing scholarship that highlights the importance of investigating climate change impacts, vulnerability and adaptation at the local scale and in the context of multiple climatic and non-climatic stressors. Importantly, the findings show that the starting-point for such an assessment needs to be with the people who are the focus of the research, to understand what conditions are relevant and important to them and what adaptations are realistic and feasible. An understanding of the local context enables us to identify the driving forces that influence vulnerability and identify strategic entry points to support adaptation.

7.3 Practical contributions

The practical contributions of this research are twofold: first, the research demonstrates the importance of taking a bottom-up approach to vulnerability assessment if the purpose of the research

is to identify opportunities to support adaptation at the local scale; and second, the research identifies practical opportunities to support adaptation efforts in Nawairuku. The approach taken in this research could inform how other climate change impacts, vulnerability, and adaptation studies are conducted in Fiji and the findings of these studies could serve as the basis for regional and national climate change adaptation strategies. In Nawairuku, the findings could be used by the village to communicate their priorities for adaptation with external parties, like governments and NGOs. For example, people in Nawairuku can use the findings of this research to have their experiences included in national and international climate change adaptation decision making. In Fiji, this means being part of the discussion on how the country intends to address climate change now and in the future. Internationally, this means being recognised in the Intergovernmental Panel on Climate Change (IPCC) report, once the findings are published, and in United Nations Framework Convention on Climate Change (UNFCCC) activities, including the Indigenous Peoples Working Group and Conference of the Parties (COP). In particular, people from Nawairuku could use the findings of this research to justify accessing funds from the Green Adaptation Fund.

7.4 Opportunities for future research

Future research could build and expand upon the key research findings. First, this study is grounded in space and time. Future research could take a longitudinal approach and repeat the study at a future point in time, and compare findings. This would provide insights into how climatic stressors manifest over time and processes of adaptation such as social learning. Second, the study could be repeated with other interior villages to develop an analogue of case studies from which we can identify common themes. Third, targeted adaptation research could be conducted in Nawairuku to further develop the issues that are identified in this research. For example, targeted research could investigate questions such food security, health, biophysical processes, and assess the effectiveness of adaptation actions.

References

Adams, J. (1995) Risk, University College London Press. London, UK.

Adger, W.N. (2006) Vulnerability. Global Environmental Change 16, 268-281.

Albert, S., Leon, J.X., Grinham, A.R., Church, J.A., Gibbes, B.R., Woodroffe, C.D. (2016) Interactions between sea-level rise and wave exposure on reef island dynamics in the Solomon Islands. Environmental Research Letters 11, 054011.

Anderson, E. (2015) smitten: From domestic bliss to domestic violence in the Cook Islands and the Timeline of Abuse. Journal of New Zealand & Pacific Studies 3, 183-206.

Anisimov, O.A., Vaughan, D.G., Callaghan, T.V., Furgal, C., Marchant, H., Prowse, T.D., Vilhjálmsson, H., Walsh, J.E. (2007) Polar regions (Arctic and Antarctic), in: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 653-685.

Aquino, D.H., Wilkinson, S.J., Raftery, G., Potangaroa, R., Chang-Richards, A. (2018) Challenges to building housing resilience: the case of Fiji post-cyclone Winston. Procedia Engineering 212, 475-480.

Armbruster, S. (2017) A year after Cyclone Winston, Fiji calls for global action on climate change, SBS News. SBS News, Crows Nest, NSW, Australia.

Arnell, N.W. (2004) Climate change and global water resources: SRES and socio-economic scenarios. Global Environmental Change 14, 31-52.

Asian Development Bank and International Food Policy Research Institute, (2009) Building Climate Resilience in the Agriculture Sector in Asia and the Pacific. Asian Development Bank and International Food Policy Research Institute, Manila, Philippines.

Asugeni, R., Esau, T., Redman-MacLaren, M., Timothy, F., Asugeni, J., MacLaren, D., Speare, R. (2016) Adapting for Life: Infrastructure responses to rising sea levels in East Kwaio, Solomon Islands. James Cook University, Unpublished work.

Australian Bureau of Meteorology, CSIRO, (2011a) Climate Change in the Pacific: Scientific Assessment and New Research. Volume 1: Regional Overview.

Australian Bureau of Meteorology, CSIRO (2011b) Climate Change in the Pacific: Scientific Assessment and New Research. Volume 2: Country Reports.

Australian Government Department of Foreign Affairs and Trade, (2018a) Fiji aid fact sheet. Department of Foreign Affairs and Trade, Canberra, Australia.

Ballu, V., Bouin, M.N., Simeoni, P., Crawford, W.C., Calmant, S., Bore, J.M., Kanas, T., Pelletier, B. (2011) Comparing the role of absolute sea-level rise and vertical tectonic motions in coastal flooding, Torres Islands (Vanuatu). Proceedings of the National Academy of Sciences of the United States of America 108, 13019-13022.

Barnett, J. (2001) Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty. World Development 29, 977-993.

Barnett, J., Campbell, J. (2010) Climate Change and Small Island States: Power, Knowledge and the South Pacific. Earthscan, London, UK and Washington, DC, USA.

Barnett, J., Chamberlain, N. (2010) Migration as Climate Change Adaptation: Implications for the Pacific. Institute of Policy Studies, Wellington.

Barnett, J., O'Neill, S.J. (2011) Islands, resettlement and adaptation. Nature Climate Change 2, 8-10.

Bebbington, A. (1999) Capitals and Capabilities. A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty. World Development 27, 2021-2044.

Bell, J.D., Ganachaud, A., Gehrke, P.C., Griffiths, S.P., Hobday, A.J., Hoegh-Guldberg, O., Johnson, J.E., Le Borgne, R., Lehodey, P., Lough, J.M., Matear, R.J., Pickering, T.D., Pratchett, M.S., Gupta, A.S., Senina, I., Waycott, M. (2013) Mixed responses of tropical Pacific fisheries and aquaculture to climate change. Nature Climate Change 3, 591-599.

Bender, S. (1991) Primer on natural hazard management in integrated regional development planning. Department of Regional Development and Environment, Executive Secretariat for Economic and Social Affairs, Organization of American States, Washington, DC.

Benwell, R. (2011) The canaries in the coalmine: small states as climate change champions. The Round Table 100, 199-211.
Berg, B. (2004) Qualitative Research Methods for the Social Sciences, 5th ed. Pearson Education, Boston.
Berg, B.L., Lune, H. (2012) Qualitative Research Methods for the Social Sciences, 8th ed. Pearson, Boston, USA.
Berkes, F., Jolly, D. (2001) Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community. Conservation Ecology 5.
Bernard, H.R. (2012) Social Research Methods: Qualitative and Quantitative Approaches. SAGE Publications.
Berrang-Ford, L., Ford, J.D., Paterson, J. (2011) Are we adapting to climate change? Global Environmental Change 21, 25-33.
Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., McNeeley, S.M. (2014) A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. Global Environmental Change 25, 97-108.
Birk, T. (2012) Relocation of Reef and Atoll Island Communities as an Adaptation to Climate Change: Learning from Experience in Solomon Islands, in: Hastrup, K., Olwig, K.F. (Eds.), Climate Change and Human Mobility: Challenges to the Social Sciences. Cambridge University Press, Cambridge, UK.
Birk, T. (2014) Assessing vulnerability to climate change and socioeconomic stressors in the Reef Islands group, Solomon Islands. Geografisk Tidsskrift-Danish Journal of Geography 114, 59-75.
Boxall, A.B., Hardy, A., Beulke, S., Boucard, T., Burgin, L., Falloon, P.D., Haygarth, P.M., Hutchinson, T., Kovats, R.S., Leonardi, G. (2009) Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture. Environmental Health Perspectives 117, 508-513.
Buggy, L., McNamara, K.E. (2016) The need to reinterpret "community" for climate change adaptation: a case study of Pele Island, Vanuatu. Climate and Development 8, 270-280.
Burkett, V., Suarez, A., Bindi, M., Conde, C., Mukerji, R., Prather, M., St. Clair, A., Yohe, G. (2014) Point of Departure in: Field, C., Barros, V., Dokken, D., Mach, K., Mastrandrea, M., Bilir, T., Chatterjee, M., Ebi, K., Estrada, Y., Genova, R., Girma, B., Kissel, E., Levy, A., MacCracken, S., Mastrandrea, P., White, L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, UK and New York, NY, pp. 169-194.
Campbell, J. (2010) An Overview of Natural Hazard Planning in the Pacific Island. The Australasian Journal of Disaster and Trauma Studies 1, 1-9.
Campbell, J.R. (2014) Development, global change and traditional food security in Pacific Island countries. Regional Environmental Change 15, 1313-1324.
Carson, M., Köhl, A., Stammer, D., Slangen, A., Katsman, C., Van de Wal, R., Church, J., White, N. (2016) Coastal sea level changes, observed and projected during the 20th and 21st century. Climatic Change 134, 269-281.
Castree, N. (2016) Broaden research on the human dimensions of climate change. Nature Climate Change 6, 731.
Cawaki, J. (2012) Drought Hit's Fiji's west, in: Hill, B. (Ed.), ABC Radio Australia.
Chambers, R. (1989) Editorial Introduction: Vulnerability, Coping and Policy. IDS Bulletin 20, 1-7.
Chandra, A., Gaganis, P. (2016) Deconstructing vulnerability and adaptation in a coastal river basin ecosystem: a participatory analysis of flood risk in Nadi, Fiji Islands. Climate and Development 8, 256-269.
Church, J.A., Clark, P.U., Cazenave, A., Gregory, J.M., Jevrejeva, S., Levermann, A., Merrifield, M.A., Milne, G.A., Nerem, R.S., Nunn, P.D., Payne, A.J., Pfeffer, W.T., Stammer, D., Unnikrishnan, A.S. (2013) Sea Level Change in: Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, 1137-1216.

Coelho, G.V. (2013) Uprooting and development: Dilemmas of coping with modernization. Springer Science & Business Media.
Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., Webb, J. (2008) A place-based model for understanding community resilience to natural disasters. Global Environmental Change 18, 598-606.
Das, S. (2012) The role of natural ecosystems and socio-economic factors in the vulnerability of coastal villages to cyclone and storm surge. Natural Hazards 64, 531-546.
Davetta, S. (2017) Provinces and Villages of Fiji. Ra Province, Suva, Fiji.
Davis, I. (1981) Disasters and the Small Dwelling: Perspectives for the UN IDNDR Pergamon Press, Oxford.
Dazé, A., Ambrose, K., Ehrhart, C., (2009) Climate Vulnerability and Capacity Analysis: Handbook. CARE International, Geneva, Switzerland.
Doney, S.C., Ruckelshaus, M., Duffy, J.E., Barry, J.P., Chan, F., English, C.A., Galindo, H.M., Grebmeier, J.M., Hollowed, A.B., Knowlton, N., Polovina, J., Rabalais, N.N., Sydeman, W.J., Talley, L.D. (2012) Climate change impacts on marine ecosystems. Annual Review of Marine Science 4, 11-37.
Downing, T., (1991) Assessing Socioeconomic Vulnerability to Famine: Frameworks, Concepts, and Applications. Final Report to the US Agency for International Development, Famine Early Warning System Project.
Duerden, F. (2004) Translating Climate Change Impacts at the Community Level. Arctic 57, 203-212.
Dumaru, P. (2010) Community-based adaptation: enhancing community adaptive capacity in Druadrua Island, Fiji. Wiley Interdisciplinary Reviews: Climate Change 1, 751-763.
Dunn, K., (2010) Interviewing, in: Hay, I. (Ed.), Qualitative Research Methods in Human Geography. Oxford University Press, Toronto, Canada, 101-137.
Duvat, V. (2013) Coastal protection structures in Tarawa Atoll, Republic of Kiribati. Sustainability Science 8, 363-379.
Ebi, K.L., Lewis, N.D., Corvalan, C. (2006) Climate Variability and Change and Their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector. Environmental Health Perspectives 14, 1957-1963.
Ellis, S., Kanowski, P., Whelan, R. (2004) National inquiry on bushfire mitigation and management.
Emery, M., Flora, C. (2006) Spiraling-Up: Mapping Community Transformation with Community Capitals Framework. Community Development 37, 19-35.
Epstein, P.R. (2005) Climate Change and Human Health. The New England Journal of Medicine 535, 1433-1436.
Farbotko, C., Lazrus, H. (2012) The first climate refugees? Contesting global narratives of climate change in Tuvalu. Global Environmental Change 22, 382-390.
Farrelly, T., Nabobo-Baba, U. (2012) Talanoa as Empathic Research, International Development Conference 2012, Auckland, New Zealand.
Fazey, I., Kesby, M., Evely, A., Latham, I., Wagatora, D., Hagasua, J.-E., Reed, M.S., Christie, M. (2010) A three-tiered approach to participatory vulnerability assessment in the Solomon Islands. Global Environmental Change 20, 713-728.
Feresi, J., Kenny, G., de Wet, N., Limalevu, L., Bhusan, J., Ratukalou, I. (2000) Climate Change Vulnerability and Adaptation Assessment for Fiji, Suva, Fiji.
Fianko, J.R., Donkor, A., Lowor, S.T., Yeboah, P.O. (2011) Agrochemicals and the Ghanaian environment, a review. Journal of Environmental Protection 2, 221.
Fidelman, P.I.J., Leitch, A.M., Nelson, D.R. (2013) Unpacking multilevel adaptation to climate change in the Great Barrier Reef, Australia. Global Environmental Change 23, 800-812.
Field, C.B., Barros, V.R., Mach, K., Mastrandrea, M. (2014) Climate change 2014: impacts, adaptation, and vulnerability. Cambridge University Press Cambridge and New York.
Fiji Bureau of Statistics, (2018) 2017 Population and Housing Census: Release 1. Age, Sex, Geography and Economic Activity, Suva, Fiji.
Fiji Department of Immigration, (2017) Research Permit. Fiji Department of Immigration, Suva, Fiji.
Fiji Meteorological Service, (2016a) Special Weather Bulletin Number One for Fiji On Severe Tropical Cyclone Winston. Fiji Meteorological Service, Nadi, Fiji.

Fiji Meteorological Service, (2016b) Special Weather Bulletin Number Fifteen for Fiji On Severe Tropical Cyclone Winston. Fiji Meteorological Service, Nadi, Fiji.
Fiji Meteorological Service, (2016c) Special Weather Bulletin Number Sixteen for Fiji On Severe Tropical Cyclone Winston. Fiji Meteorological Service, Nadi, Fiji.
Fiji Ministry of Communications, (2016) Help for Homes Initiative - Information Background. Fiji Government, Ministry of Communications, Suva, Fiji.
Fletcher, S.M., Thiessen, J., Gero, A., Rumsey, M., Kuruppu, N., Willetts, J. (2013) Traditional coping strategies and disaster response: Examples from the South Pacific region. Journal of Environmental and Public Health 2013.
Flora, C., Emery, M., Fey, S.G., Bregendahl, C. (2004) Community Capitals: A Tool for Evaluating Strategic Intervention Projects. Iowa State University, Ames, Iowa, USA.
Folke, C., Hahn, T., Olsson, P., Norberg, J. (2005) Adaptive Governance of Social-Ecological Systems. Annual Review of Environment and Resources 30, 441-473.
Forbes, D.L., James, T.S., Sutherland, M., Nichols, S.E. (2013) Physical basis of coastal adaptation on tropical small islands. Sustainability Science 8, 327-344.
Ford, J.D. (2012b) Indigenous Health and Climate Change. American Journal of Public Health 102, 1260-1266.
Ford, J.D., Bolton, K., Shirley, J., Pearce, T., Trembley, M., Westlake, M. (2012) Mapping Human Dimensions of Climate Change Research in the Canadian Arctic. Ambio 41, 808-822.
Ford, J.D., Keskitalo, E., Smith, T., Pearce, T., Berrang-Ford, L., Duerden, F., Smit, B. (2010) Case study and analogue methodologies in climate change vulnerability research. Wiley Interdisciplinary Reviews: Climate Change 1, 374-392.
Ford, J.D., McDowell, G., Pearce, T. (2015) The adaptation challenge in the Arctic. Nature Climate Change 5, 1046-1053.
Ford, J.D., Smit, B. (2004) A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change. Arctic 57, 389-400.
Ford, M. (2012a) Shoreline Changes on an Urban Atoll in the Central Pacific Ocean: Majuro Atoll, Marshall Islands. Journal of Coastal Research 279, 11-22.
Fox, S. (2002) These are Things That are Really Happening: Inuit Perspectives on the Evidence and Impacts of Climate Change in Nunavut, in: Krupnik, I., Jolly, D. (Eds.), The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change. Arctic Research Consortium of the United States, Fairbanks, Alaska, USA,12-53.
Fujieda, A., Kobayashi, H. (2013) The Potential of Fijian Traditional Housing to Cope with Natural Disasters in Rural Fiji.
Füssel, H., M, Klein, R.J. (2006) Climate Change Vulnerability Assessments: An Evolution of Conceptual Thinking. Climatic Change 75, 301-329.
Ganase, S.A.S., Teelucksingh, S.S. (2012) Linking Vulnerability, Adaptation and Mitigation in Small Island Developing States: Climate Change and the Community of Grande Reviere, Trinidad. University of the West Indied, Trinidad & Tobago Belpasso, Italy.
Gilman, E.L., Joanna Ellison, J., Jungblut, V., Van Lavieren, H., Wilson, L., Areki, F., Brighouse, B., Bungitak, J., Dus, E., Henry, M., Kilman, M., Matthews, E., Sauni Jr., I., Teariki-Ruatu, N., Tukia, S., Yuknavage, K. (2006) Adapting to Pacific Island mangrove responses to sea level rise and climate change. Climate Research 32, 161-176.
Glavovic, B.C., Smith, G.P. (2014) Adapting to climate change: lessons from natural hazards planning Springer.
Government of Fiji, (2016) Fiji Post-Disaster Needs Assessment. Tropical Cyclone Winston, February 20, 2016. Government of Fiji, Suva, Fiji.
Gromilova, M. (2014) Revisiting Planned Relocation as a Climate Change Adaptation Strategy: The Added Value of a Human Rights-Based Approach. Utrecht Law Review 10, 76-95.
Gutierrez-Montes, I., Emery, M., Fernandez-Baca, E. (2009) The Sustainable Livelihoods Approach and the Community Capitals Framework: The Importance of System-Level Approaches to Community Change Efforts. Community Development 40, 106-113.
Hanich, Q., Wabnitz, C.C., Ota, Y., Amos, M., Donato-Hunt, C., Hunt, A. (2018) Small-scale fisheries under climate change in the Pacific Islands region. Marine Policy 88, 279-284.

Hartmann, D.L., Klein Tank, A.M., Rusticucci, M., Alexander, L.V., Brönnimann, S., Charabi, Y.A.R., Dentener, F.J., Dlugokencky, E.J., Easterling, D.R., Kaplan, A., Soden, B.J., Thorne, P.W., Wild, M., Zhai, P. (2013) Observations: Atmosphere and Surface, in: Hurrel, J., Marengo, J., Tangang, F., Viterbo, P. (Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY,159-254.
Hau'ofa, E. (1994) Our Sea of Islands. The Contemporary Pacific 6, 148-161.
Hauriasi, A., Davey, H. (2009) Accounting and culture. Pacific Accounting Review 21, 228-259.
Henrich, J., Henrich, N. (2004) Fairness Without Punishment: Behavioral Experiments in the Yasawa Islands, Fiji, in: Ensminger, J., Henrich, J. (Eds.), Experimenting with Social Norms: Fairness and Punishment in Cross-Cultural Perspective. Russell Sage Press, New York, USA.
Hernández-Delgado, E.A. (2015) The emerging threats of climate change on tropical coastal ecosystem services, public health, local economies and livelihood sustainability of small islands: Cumulative impacts and synergies. Mar Pollut Bull 101, 5-28.
Hewitt, K. (1998) Excluded perspectives in the social construction of disaster, in: Quarantelli, E. (Ed.), What is a Disaster? Routeledge, London, UK, 75-91.
Hoeke, R.K., McInnes, K.L., Kruger, J.C., McNaught, R.J., Hunter, J.R., Smithers, S.G. (2013) Widespread inundation of Pacific islands triggered by distant-source wind-waves. Global and Planetary Change 108, 128-138.
Hunter, P.R., MacDonald, A.M., Carter, R.C. (2010) Water supply and health. PLoS Med 7, 1-9.
Huq, S., Rahman, A., Konate, M., Sokona, Y., Reid, H. (2003) Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCs), London.
Hviding, E. (2006) Knowing and managing biodiversity in the Pacific Islands: challenges of environmentalism in Marovo Lagoon. International Social Science Journal 58, 69-85.
IPCC, (2001) Annex B. Glossary of Terms, in: Dokken, D.J., Noguer, M., van der Linden, P.J., Johnson, C., Pan, R., Taniguchi, T., Zhou, D. (Eds.), Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA.
IPCC, (2014a) Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change in: CoreWritingTeam, Pachauri, R.K., Meyer, L.A. (Eds.), Geneva, Switzerland, 151.
IPCC, (2014b) Coastal Systems and Low-Lying Areas, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA.
Johnston, I. (2014) Disaster management and climate change adaptation: a remote island perspective. Disaster Prevention and Management 23, 123-137.
Kates, R. (1985) The Interactions of Climate and Society.pdf>, in: Kates, R., Ausubel, J., Berberian, M. (Eds.), Climate Impact Assessment: Studies of the Interaction of Climate and Society. John Wiley, Chichester UK and New York, NY, USA, 3-36.
Kates, R.W., Travis, W.R., Wilbanks, T.J. (2012) Transformational adaptation when incremental adaptations to climate change are insufficient. Proceedings of the National Academy of Sciences of the United States of America 109, 7156-7161.
Kelly, P., Adger, W. (2000) Theory and Practice in Assessing Vulnerability to Climate Change and Facilitating Adaptation Climatic Change 47, 325-352.
Kench, P.S., Owen, S.D. (2015) Coral Reef Systems and the Complexity of Hazards. 431-465.
King, D., Bird, D., Haynes, K., Boon, H., Cottrell, A., Millar, J., Okada, T., Box, P., Keogh, D., Thomas, M. (2014) Voluntary relocation as an adaptation strategy to extreme weather events. International Journal of Disaster Risk Reduction 8, 83-90.
Klein, R., Eriksen, S., Næss, L., Hammill, A., Tanner, T., Robledo, C., KL, O.B. (2007) Portfolio screening to support the mainstreaming of adaptations to climate change into development assistance. Tyndall Centre for Climate Change Research.
Kovács-Hostyánszki, A., Espíndola, A., Vanbergen, A.J., Settele, J., Kremen, C., Dicks, L.V. (2017) Ecological intensification to mitigate impacts of conventional intensive land use on pollinators and pollination. Ecology letters 20, 673-689.

Krantz, L. (2001) The Sustainable Livelihood Approach to Poverty Reduction: An Introduction. Swedish International Development Cooperation Agency, Stockholm.
Krishna, R. (1981) Publication No. 2: Tropical Cyclones in Fiji: November 1969 – April 1980 Fiji Meteorological Service, Suva, Fiji.
Kumar, R., Stephens, M., Weir, T. (2014) Rainfall trends in Fiji. International Journal of Climatology 34, 1501-1510.
Kuruppu, N., Liverman, D. (2011) Mental preparation for climate adaptation: The role of cognition and culture in enhancing adaptive capacity of water management in Kiribati. Global Environmental Change 21, 657-669.
Lauer, M., Aswani, S. (2010) Indigenous knowledge and long-term ecological change: detection, interpretation, and responses to changing ecological conditions in Pacific Island communities. Environmental Management 45, 985-997.
Lebel, L. (2012) Local knowledge and adaptation to climate change in natural resource-based societies of the Asia-Pacific. Mitigation and Adaptation Strategies for Global Change 18, 1057-1076.
Lede, E. (2018) Adaptation to Climate Change in the Context of Multiple Stressors in the Canadian Arctic, Faculty of Arts, Business and Law. University of the Sunshine Coast, Sippy Downs, Australia.
Lefale, P.F. (2010) Ua ‘afa le Aso Stormy weather today: traditional ecological knowledge of weather and climate. The Samoa Experience. Climatic Change 100, 317-335.
Leon, J.X., Hardcastle, J., James, R., Albert, S., Kereseka, J., Woodroffe, C.D. (2015) Supporting Local and Traditional Knowledge with Science for Adaptation to Climate Change: Lessons Learned from Participatory Three-Dimensional Modeling in BoeBoe, Solomon Islands. Coastal Management 43, 424-438.
Leonard, S., Parsons, M., Olawsky, K., Kofod, F. (2013) The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberley, Australia. Global Environmental Change 23, 623-632.
Lewis, D. (1971) 'Expanding' the Target in Indigenous Navigation. The Journal of Pacific History 6, 83-95.
Madin, E.M.P., Ban, N.C., Doubleday, Z.A., Holmes, T.H., Pecl, G.T., Smith, F. (2012) Socio-economic and management implications of range-shifting species in marine systems. Global Environmental Change 22, 137-146.
Magauzi, R., Mabaera, B., Rusakaniko, S., Chimusoro, A., Ndlovu, N., Tshimanga, M., Shambira, G., Chadambuka, A., Gombe, N. (2011) Health effects of agrochemicals among farm workers in commercial farms of Kwekwe district, Zimbabwe. Pan African Medical Journal 9, 26.
Magee, A.D., Verdon-Kidd, D.C., Kiem, A.S., Royle, S.A. (2016) Tropical cyclone perceptions, impacts and adaptation in the Southwest Pacific: an urban perspective from Fiji, Vanuatu and Tonga. Natural Hazards and Earth System Sciences 16, 1091-1105.
Magnan, A. (2014) Avoiding maladaptation to climate change: towards guiding principles. Sapiens 7, 1-11.
Mangubhai, S. (2016) Impact of Tropical Cyclone Winston on Coral Reefs in the Vatu-i-Ra Seascape, Report No. 01/16. Wildlife Conservation Society, Suva, Fiji, 27.
Maru, Y.T., Stafford Smith, M., Sparrow, A., Pinho, P.F., Dube, O.P. (2014) A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities. Global Environmental Change 28, 337-350.
Marzloff, M.P., Melbourne-Thomas, J., Hamon, K.G., Hoshino, E., Jennings, S., van Putten, I.E., Pecl, G.T. (2016) Modelling marine community responses to climate-driven species redistribution to guide monitoring and adaptive ecosystem-based management. Global Change Biology 22, 2462-2474.
Maskrey, A. (1989) Disaster Mitigation: A Community Based Approach. Oxfam, Oxford.
McCarter, J., Gavin, M.C. (2011) Perceptions of the value of traditional ecological knowledge to formal school curricula: opportunities and challenges from Malekula Island, Vanuatu. Journal of Ethnobiology and Ethnomedicine 7, 38.
McCubbin, S., Smit, B., Pearce, T. (2015) Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. Global Environmental Change 30, 43-55.

McDowell, J.Z., Hess, J.J. (2012) Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. Global Environmental Change 22, 342-352.
McIver, L., Kim, R., Woodward, A., Hales, S., Spickett, J., Katscherian, D., Hashizume, M., Honda, Y., Kim, H., Iddings, S. (2016) Health impacts of climate change in Pacific island countries: a regional assessment of vulnerabilities and adaptation priorities. Environmental Health Perspectives 124, 1707.
McIver, L., Kim, R., Woodward, A., Hales, S., Spickett, J., Katscherian, D., Hashizume, M., Honda, Y., Kim, H., Iddings, S., Naicker, J., Bambrick, H., McMichael, A.J., Ebi, K.L. (2015) Health Impacts of Climate Change in Pacific Island Countries: A Regional Assessment of Vulnerabilities and Adaptation Priorities. Environmental Health Perspectives 124, 1707-1714.
McLean, J.E. (2015) Beyond the pentagon prison of SLA and towards livelihood trajectories approaches. Asia Pacific Viewpoint 56, 380-391.
McLean, R., Kench, P. (2015) Destruction or persistence of coral atoll islands in the face of 20th and 21st century sea-level rise? Wiley Interdisciplinary Reviews: Climate Change 6, 445-463.
McMichael, A.J., Campbell-Lendrum, D.H., Corvalán, C.F., Ebi, K.L., Githeko, A.K., Scheraga, J.D., Woodward, A. (2003) Climate change and human health: Risks and responses. World Health Organization, Geneva, Switzerland.
McNamara, K.E. (2013) Taking stock of community-based climate-change adaptation projects in the Pacific. Asia Pacific Viewpoint 54, 398-405.
Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., van der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C., Nelson, D.R. (2010) Resilience and Vulnerability: Complementary or Conflicting Concepts? Ecology and Society 15.
Mimura, N. (2013) Sea-level rise caused by climate change and its implications for society. Proceedings of the Japan Academy, Series B 89, 281-301.
Mimura, N., Nurse, L., McLean, R., Agard, J., Briguglio, L., Lefale, P., Payet, R., Sem, G. (2007) Small Islands Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA.
Miyaji, M., Fujieda, A., Waqalevu, S., Kobayashi, H. (2017) Challenges for self-recovery from cyclone disasters in a traditional Fijian village: The case of Navala village after Tropical Cyclone Winston. Disaster Management and Human Health Risk: Reducing Risk, Improving Outcomes 173, 161-172.
Moberg, F., Folke, C. (1999) Ecological goods and services of coral reef ecosystems. Ecological Economics 29, 215-233.
Mondragón, C. (2004) Of Winds, Worms and Mana: The Traditional Calendar of the Torres Islands, Vanuatu. Oceania 71, 289-308.
Morton, J.F. (2007) The impact of climate change on smallholder and subsistence agriculture. Proceedings of the National Academy of Sciences 104, 19680-19685.
Mortreux, C., Barnett, J. (2009) Climate change, migration and adaptation in Funafuti, Tuvalu. Global Environmental Change 19, 105-112.
Movono, A., Dahles, H. (2017) Female empowerment and tourism: a focus on businesses in a Fijian village. Asia Pacific Journal of Tourism Research 22, 681-692.
Movono, A., Dahles, H., Becken, S. (2018) Fijian culture and the environment: a focus on the ecological and social interconnectedness of tourism development. Journal of Sustainable Tourism 26, 451-469.
Nabhan, G.P. (2010) Perspectives in ethnobiology: ethnophenology and climate change. Journal of Ethnobiology 30, 1-4.
Nabobo, U., Teasdale, J. (1994) Teacher education for cultural identity in Fiji. Directions 16, 3-13.
Nabobo-Baba, U. (2006) Knowing and Learning: An Indigenous Fijian Approach. Institute of Pacific Studies, University of the South Pacific, Suva, Fiji.
Nabobo-Baba, U. (2008) Decolonising Framings in Pacific Research: Indigenous Fijian Vanua Research Framework as an Organic Response. Alternative 4, 140-154.
Nakashima, D., Galloway McLean, K., Thulstrup, H., Ramos Castillo, A., Rubis, J. (2012) Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation. UNESCO & ANU, Paris & Darwin.

Nakashima, D., Nilsson, A., (2006) Linking biological and cultural diversity Local and Indigenous Knowledge Systems (LINKS) project, in: Petitjean, P., Zharov, V., Glaser, G., Richardson, J., de Padirac, B., Archibald, G. (Eds.), Sixty Years of Science at UNESCO 1945-2005. UNESCO, Paris, France, 385-388.
NASA, (2016) Tropical Cyclone Winston Slams Fiji. NASA, Houston, Texas, USA.
Native Land Trust Board, (2018) Native Land Trust Board Facts. Native Land Trust Board, Suva, Fiji.
Nelson, G.C., Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M. (2009) Climate change: Impact on agriculture and costs of adaptation. The International Food Policy Research Institute
Newing, H. (2010) Conducting research in conservation: Social science methods and practice. Routledge, New York.
Nolet, E. (2016) 'Are you prepared?' Representations and management of floods in Lomanikoro, Rewa (Fiji). Disasters 40, 720-739.
Normille, D. (2016) El Niño's warmth devastating reefs worldwide. Science 352, 15-16.
Nunn, P.D. (2009) Responding to the challenges of climate change in the Pacific Islands: management and technological imperatives. Climate Research 40, 211-231.
Nunn, P.D. (2013) The end of the Pacific? Effects of sea level rise on Pacific Island livelihoods. Singapore Journal of Tropical Geography 34, 143-171.
Nunn, P.D., Aalbersberg, W., Lata, S., Gwilliam, M. (2014) Beyond the core: community governance for climate-change adaptation in peripheral parts of Pacific Island Countries. Regional Environmental Change 14, 221-235.
Nurse, L.A., McLean, R.F., Agard, J., Briguglio, L.P., Duvat-Magnan, V., Pelesikoti, N., Tompkins, E., Webb, A. (2014) Small Islands in: Field, C., Barros, V., Dokken, D., Mach, K., Mastrandrea, M., Bilir, T., Chatterjee, M., Ebi, K., Estrada, Y., Genova, R., Girma, B., Kissel, E., Levy, A., MacCracken, S., Mastrandrea, P., White, L. (Eds.), Small islands. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA, 1613-1654.
Nurse, L.A., Sem, G., Hay, J.E., Suarez, A.G., Wong, P.P., Briguglio, L.P., Ragooneden, S. (2001) Small Island States, in: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 843-875.
O'Brien, G., O'Keefe, P., Gadema, Z., Swords, J. (2010) Approaching disaster management through social learning. Disaster Prevention and Management: An International Journal 19, 498-508.
O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., Javed, A., Bhadwal, S., Barg, S., Nygaard, L. (2004) Mapping vulnerability to multiple stressors: climate change and globalization in India. Global Environmental Change 14, 303-313.
Pacific Beat, (2016) Fiji floods: Days of torrential rain cause severe flooding and landslides, with more rain forecast. ABC News, Suva.
Paeniu, L., Iese, V., Combes, D., ADR, N.Y., Korovulavula, I., Koroi, A., Sharma, P., Hobgood, N., Chung, K., Devi, A. (2015) Best Practices in Coastal Protection for the Pacific, Suva, Fiji.
Panthi, J., Aryal, S., Dahal, P., Bhandari, P., Krakauer, N., Pandey, V. (2016) Livelihood vulnerability approach to assessing climate change impacts on mixed agro-livestock smallholders around the Gandaki River Basin in Nepal. Regional Environmental Change 16, 1121-1132.
Patton, M.Q. (2014) Qualitative Research & Evaluation Methods: Integrating Theory and Practice. SAGE Publications.
Pearce, T., Currenti, R., Mateiwai, A., Doran, B. (2018) Adaptation to climate change and freshwater resources in Vusama village, Viti Levu, Fiji. Regional Environmental Change 18, 501-510.
Pearce, T., Ford, J., Willox, A.C., Smit, B. (2015a) Inuit Traditional Ecological Knowledge (TEK) Subsistence Hunting and Adaptation to Climate Change in the Canadian Arctic. Arctic 68, 233.
Pearce, T., Ford, J.D., Smit, B., Duerden, F., Furgal, C.M., Dawson, J., B, B. (2015b) Chapter 10 Factors of Adaptation: climate change policy responses for Canada's Inuit, in: Stern, G.A., Gaden, A. (Eds.), ArcticNet IRIS I Regional Impact Assessment, ArcticNet, Laval University, Canada, 403-427.

Pearce, T., Smit, B., Duerden, F., Ford, J.D., Goose, A., Kataoyak, F. (2010) Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. Polar Record 46, 157.
Pearce, T.D., Ford, J.D., Laidler, G.J., Smit, B., Duerden, F., Allarut, M., Andrachuk, M., Baryluk, S., Dialla, A., Elee, P., Goose, A., Ikummaq, T., Joamie, E., Kataoyak, F., Loring, E., Meakin, S., Nickels, S., Shappa, K., Shirley, J., Wandel, J. (2009) Community collaboration and climate change research in the Canadian Arctic. Polar Research 28, 10-27.
Pelling, M. (2010) Adaptation to climate change: from resilience to transformation. Routledge.
Pendleton, L.H., Hoegh-Guldberg, O., Langdon, C., Comte, A. (2016) Multiple Stressors and Ecological Complexity Require a New Approach to Coral Reef Research. Frontiers in Marine Science 3, 1-5.
Petheram, L., Zander, K., Campbell, B.M., High, C., Stacey, N. (2010) 'Strange changes': Indigenous perspectives of climate change and adaptation in NE Arnhem Land (Australia). Global Environmental Change 20, 681-692.
Prasad, R. (1993) Tropical Cyclone Kina, December 26, 1992 – January 5, 1993 (Tropical Cyclone Report 92/1). Fiji Meteorological Service, Suva, Fiji.
Prober, S.M., O'Connor, M.H.O., Walsh, F.J. (2011) Australian Aboriginal Peoples' Seasonal Knowledge: A Potential Basis for Shared Understanding in Environmental Management. Ecology and Society 16.
Quarantelli, E.L. (2005) What is a disaster?: A dozen perspectives on the question. Routledge.
Quinlan, M. (2005) Considerations for Collecting Freelists in the Field: Examples from Ethnobotany. Field methods 17, 219-234.
Ratuva, S. (2002) Anatomizing the vanua concept: Intra-communal land disputes and implications on the Fijian community, Conference on South Pacific Land Tenure Conflict Symposium, University of the South Pacific, Suva, Fiji.
Reed, M., Podesta, G., Fazey, I., Geeson, N., Hessel, R., Hubacek, K., Letson, D., Nainggolan, D., Prell, C., Rickenbach, M. (2013) Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. Ecological Economics 94, 66-77.
Reenberg, A., Birch, T., T, Mertz, O., Fog, B., Christiansen, S. (2008) Adaptation of Human Coping Stategies in a Small Island Society in the SW Pacific - 50 Years of Change in the Coupled Human-Environment System on Bellona, Solomon Islands. Human Ecology 36, 807-819.
ReliefWeb, (2016) Tropical Depression TD04F - Dec 2016. ReliefWeb.
Riedlinger, D. (1999) Climate Change and the Inuvialuit of Banks Island, NWT: Using Traditional Environmental Knowledge to Complement Western Science. Arctic 52, 430-432.
Robinson, S.-a. (2017) Mainstreaming climate change adaptation in small island developing states. Climate and Development 2017, 1-13.
Saldajeno, P.B., Florece, L.M., Lasco, R.D., Velasco, M.T.H. (2012) Vulnerability Assessment of Upland Communities in Sibalon Natural Park, Antique, Using Capital-based Approach. Journal of Environmental Science and Management 15, 1-12.
Salinger, M., Basher, R., Fitzharris, B., Hay, J., Jones, P., MacVeigh, J., Schmidely-Leleu, I. (1995) Climate trends in the south-west Pacific. International Journal of Climatology 15, 285-302.
Santha, S.D. (2015) Adaptation to coastal hazards: the livelihood struggles of a fishing community in Kerala, India. Disasters 39, 69-85.
Seidel, H., Lal, P.N. (2010) Economic Value of the Pacific Ocean to Pacific Island Countries and Territories. IUCN, Gland, Switzerland, 74.
Sen, A. (1981) Poverty and Famines: An Essay on Entitlement and Deprivation. Clarendon Press, Oxford.
Sen, A. (1990) Entitlements and the Chinese Famine. Food Policy June, 261-262.
Seneviratne, S., Nichols, N., Easterling, D., Goodess, C., Kanae, S., Kossin, J., J, M., McInnes, K.L., Rahimi, M., Peichstein, M., Sorteberg, A., Vera, C., Zhang, X. (2012) Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, in: Field, C., Barros, V., Stocker, T., Qin, D., Dokken, D., Ebi, K., Mastrandrea, M., Mach, K., Plattner, G., Allen, D.M., Tignor, M., Midgley, P. (Eds.), A Special Report of Working Groups I and II of the

Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, 109-230.
Shelter Cluster Fiji, (2016) Help for Homes: Tips to Build Back Safer. Shelter Cluster, Unpublished work.
Sidle, R.C., Benson, W.H., Carriger, J.F., Kamai, T. (2013) Broader perspective on ecosystem sustainability: consequences for decision making. Proceedings of the National Academy of Sciences of the United States of America 110, 9201-9208.
Silaitoga, S. (2015) Water use restrictions, The Fiji Times. The Fiji Times, Suva, Fiji.
Singh, R.B.K., Hales, S., de Wet, N., Raj, R., Hearden, M., Weinstein, P. (2001) The Influence of Climate Variation and Change on Diarrheal Disease in the Pacific Islands. Environmental Health Perspectives 109, 155-159.
Singh, S., Eghdami, M., Singh, S. (2014) The Concept of Social Vulnerability. A Review from Disasters Perspectives. International Journal of Interdisciplinary and Multidisciplinary Studies 1, 71-82.
Slezak, M. (2016) Massive mangrove die-off on Gulf of Carpentaria worst in the world, says expert. The Guardian.
Smit, B., Burton, I., Klein, R., Wandel, J. (2000) An Anatomy of Adaptation to Climate Change and Variability. Climatic Change 45, 223-251.
Smit, B., Pilifosova, O. (2003) From adaptation to adaptive capacity and vulnerability reduction, in: Smith, B., Klein, R.J.T., Huq, S. (Eds.), Climate Change, Adaptive Capacity and Development. Imperial College Press, London.
Smit, B., Pilifosova, O., Burton, I., Challenger, I., Huq, S., Klein, R., Yohe, G., Adger, N., Downing, T., E Harvey, E., Kane, S., Parry, M., Skinner, M., Smith, J. (2001) Adaptation to Climate Change in the Context of Sustainable Development and Equity, Impacts, Adaptation, and Vulnerability, 877-912.
Smit, B., Skinner, M. (2002) Adaptation options in agriculture to climate change. A typology. Mitigation and Adaptation Strategies for Global Change 7, 85-114.
Smit, B., Wandel, J. (2006) Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16, 282-292.
Smith, L.T. (1999) Decolonising methodologies: Research and Indigenous peoples. Zed Books, London.
Sovacool, B.K. (2011) Hard and soft paths for climate change adaptation. Climate Policy 11, 1177-1183.
Spennemann, D.H.R. (2006) Freshwater Lens, Settlement Patterns, Resource Use and Connectivity in the Marshall Islands. Transforming Cultures eJournal 1, 44-63.
SPREP, (2016) New PacWaste documentary captures regional collaboration in action. SPREP, Apia, Samoa.
Stevenson, M.G. (1996) Indigenous Knowledge in Environmental Assessment. Arctic 49, 278-291.
Stocker, T., Qin, D., Plattner, G., Tignor, M., Allen, S., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P. (2013) IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 1535. Cambridge Univ. Press, Cambridge, UK, and New York.
Sutherland, K., Smit, B., Wulf, V., Nakalevu, T. (2005) Vulnerability in Samoa. Tiempo 54, 11-15.
Terry, J.P. (2007) Tropical cyclones: climatology and impacts in the South Pacific. Springer Science & Business Media.
Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., Rockström, J. (2006) Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation Disasters 30, 39-48.
Timmerman, P. (1981) Vulnerability, Resilience and the Collapse of Society: A Review of Models and Possible Climatic Applications. Institute for Environmental Studies, Toronto.
Turner, B., Kasperson, R., Matson, P., McCarthy, J., Corell, R., Christensen, L., Eckley, N., Kasperson, J., Luers, A., Martello, M., Polsky, C., Pulsipher, A., Schiller, A. (2003) A framework for vulnerability analysis in sustainability science. PNAS 100, 8074-8079.
Turral, H., Burke, J., Faurès, J.-M., (2011) Climate change water and food security. FAO, Rome, Italy.

United Nations Office for the Coordination of Humanitarian Affairs, (2013) Disaster Response in Asia and the Pacific. A Guide to International Tools and Services. United Nations Office for the Coordination of Humanitarian Affairs, Bangkok, Thailand.
United States Geological Survey, (2004) Landslide Types and Processes.
Usher, P.J. (2000) Traditional Ecological Knowledge in Environmental Assessment and Management. Arctic 53, 183-193.
van Vuuren, D.P., Kriegler, E., O'Neill, B.C., Ebi, K.L., Riahi, K., Carter, T.R., Edmonds, J., Hallegatte, S., Kram, T., Mathur, R., Winkler, H. (2014) A new scenario framework for Climate Change Research: scenario matrix architecture. Climatic Change 122, 373-386.
Wabnitz, C., Taylor, M., Green, E., Razak, T. (2003) From Ocean to Aquarium: The Global trade in marine ornamental species. UNEP-MCMC, Cambridge, UK.
Walsh, K.J.E., McInnes, K.L., McBride, J.L. (2012) Climate change impacts on tropical cyclones and extreme sea levels in the South Pacific — A regional assessment. Global and Planetary Change 80-81, 149-164.
Warrick, O., Lal, P.N., Joel, L., Hoag, P. (2013) The adaptive capacity of the Tegua Island community, Torres Islands, Vanuatu. Commonwealth of Australia, Canberra, Australia.
Watts, M., Bohle, H. (1993) The space of vulnerability: the causal structure of hunger and famine. Progress in Human Geography 17, 43-67.
Wenzel, G.W. (1999) Traditional Ecological Knowledge and Inuit: Reflections on TEK Research and Ethics. Arctic 52, 113-124.
Westerhoff, L., Smit, B. (2009) The rains are disappointing us: dynamic vulnerability and adaptation to multiple stressors in the Afram Plains, Ghana. Mitigation and Adaptation Strategies for Global Change 14, 317-337.
Wheeler, T., von Braun, J. (2013) Climate change impacts on global food security. Science 341, 508-513.
Why, S., Tuwai, I. (2005) Fiji Live Rock Harvesting Assessment: Findings and Recommendations. NOAA-NODC, Unpublished report.
Willox, A.C., Harper, S.L., Ford, J.D., Edge, V.L., Landman, K., Houle, K., Blake, S., Wolfrey, C. (2013) Climate change and mental health: an exploratory case study from Rigolet, Nunatsiavut, Canada. Climatic Change 121, 255-270.
Wisner, B. (1988) Power and Need in Africa: Basic Human Needs and Development Policies. Earthscan and Africa World Press., London and Trenton, New Jersey.
Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2003) At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge.
Wolcott, H.F. (1995) The art of fieldwork. Walnut Creek. California., AltaMira Press.
Wong, P.P., Losada, I.J., Gattuso, J.-P., Hinkel, J., Khattabi, A., McInnes, K.L., Saito, Y., Sallenger, A. (2014) Coastal Systems and Low-Lying Areas, in: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA, 361-409.
Woodward, A., Hales, S., Weinstein, P. (1998) Climate change and human health in the Asia Pacific region: who will be most vulnerable? Climate Research 11, 31-38.
Yeo, S.W., Blong, R.J., McAneney, K.J. (2007) Flooding in Fiji: findings from a 100-year historical series. Hydrological Sciences Journal 52, 1004-1015.
Yohe, G., Tol, R.S.J. (2002) Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. Global Environmental Change 12, 25-40.

Appendices

Appendix 1 Vanua Research Framework

The global movement to 'decolonise' research methodologies when carrying out Indigenous research has resulted in the development of Indigenous research methodologies, protocols and practices, including the *Vanua* Research Framework for Fiji (Nabobo-Baba 2006; 2008). The framework has eight principles aimed at achieving ethical, equitable and locally accepted research.

Key principles of the Vanua Research Framework
Adapted from Nabobo-Baba 2008

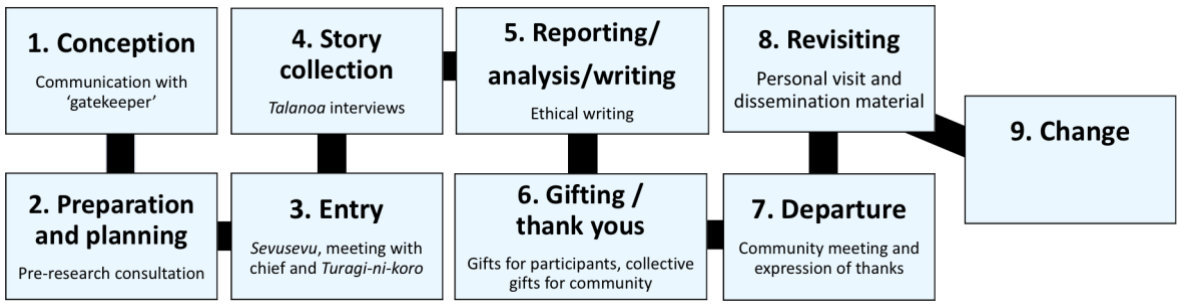
1. The research **benefits all people**, particularly those of Nawairuku. By uncovering the conditions that effect lives and livelihoods of a majorly underrepresented population, this research brings light to unique challenges and highlights way forward. Pre-research communication and consultation ensured the needs of the villagers were met and the research was conducted in a suitable manner for them. Communication prior to the pre-research consultation was via email with the chairman of the village development committee (Appendix 3). Community involvement in research design and development gave the community a voice in research and allowed the researcher to learn from the community and design a study with **tangible value to the community**. Effort was made to gain the insights of commonly marginalised peoples such as the elderly and women.
2. The research had a **primary focus on the needs of Indigenous people**, **taking into account Indigenous cultural values and protocols**. Research findings concern daily livelihoods and contribute to the body of knowledge relating to climate change and the effects on Pacific Island populations. The researcher spent two weeks building rapport in the community before commencing facilitation of interviews. These weeks were spent getting to know individuals on a personal basis, and becoming aware of local culture and practices that were important for the interviewing process.

3. **Fluency in the Fijian language (Ra dialect)** was poor and this principle has great room for improvement. While the research made effort to learn some Ra dialect, competency did not extend far beyond daily greetings, name of local crops and household commands. Dependency on the local research partner was vital to communicate with some interview participants, especially the elderly (>50 years).
4. The **inclusion of local research partners** was paramount for the success of this research project. Local research assistants participated in the research and shared their knowledge and experiences of dealing with environmental changes through semi-structured interviews. The inclusion of local research partners further engaged the community, leading to greater levels of participation and allowed for better communication within the community, providing valuable support in interpretation and verification of data and results.
5. **Respect was constantly expressed** through **acknowledgement of *Vanua* structures and protocols**. **Appreciation** for people's love, support, time, resources and knowledge given freely to the research **was reciprocated** and expressed through gifting of household and food goods, toys for children, stationery for school-aged children and financial support for research partners.
6. **Accountability was held** by the researcher and **meaningful reporting was shared with the research community and other relevant people** including representatives of the Commissioner Western Division Office and Provincial Council. Results were disseminated in a culturally appropriate manner in the case study community prior to other forms of dissemination to verify interpretations and representations of data. Upon consent, the community was also given a copy of all data and findings. Results were shared with the community through a personal visit, a plain language summary booklet and photobooks. Results will also be shared in peer-reviewed journals, poster presentations and at academic conferences.
7. **Permission was granted by the village chief and leaders** prior to the commencement of the research. The research, like any important occasion, began and ended with a formal kava ceremony known as a *sevusevu*. A *sevusevu* is a formal offering and presentation of *waka* (dried roots of the *yaqona* plant) by researchers to the village chief and leaders and is the only culturally appropriate means of initiating a collaborative relationship between communities and researchers. A *sevusevu* is vital to communicate the purpose of the research and formally request consent for the research to go ahead with the acceptance implying communal consent for all members of the community to be involved (Nabobo-Baba, 2006).

Through applying the principles, the research followed the steps identified by Nabobo-Baba (2008) essential for Vanua research (below). Examples of how the research followed each step is provided in respective boxes. The eighth step in the process, "revisiting" will be conducted in May 2018 through a personal visit to the village for dissemination and verification of findings. It is expected the publication and presentation of findings on various platforms and to relevant bodies will

contribute to the ninth step in the process, "change". Research results will be disseminated in peer-reviewed publications, conference posters and presentations, student theses, and a plain-language summary report (translated to English and Fijian). Participants will be given transcripts of their interviews and, upon consent obtained during interviews, audio files will be returned to the community. The research engaged with local research partners throughout all stages of the research project, including the writing and dissemination of findings. Engaging with local research partners throughout the writing phase of the project allowed validation to ensure rigour and affirmed the collaboration between the researcher and the community of Nawairuku.

The steps of Vanua research



Source: Nabobo-Baba 2008

Appendix 2 Interview Guide

Adaptation to Climate Change in Nawairuku Village, Ra, Fiji
Interview Guide

Date:
Interview by:

Attachment #1: Socio-demographic Interview

1.	Interview # Name for recording purposes	
2.	Gender	
3.	Age	
4.	Length of time in village; name of maiden village (if applicable)	
5.	Highest level of schooling	
6.	Social contribution (e.g. job, status)	
7.	Household characteristics (who lives in the house? How many children? Are all in the village? If not, where, doing what?	
8.	Food production activities (does anyone in the household fish, farm, keep animals, etc.?)	
9.	Distant experience (have you lived outside Newark? Where? For how long?)	
10.	Do you plan to stay in Nawairuku? Your children? Why not, if applicable?	

Notes: *[describe the setting, time of day, place, and context for discussion]*

Interview Guide (continued)

Attachment #2: Semi-Structured Interview Guide

The following is a set of questions about stresses to livelihoods and response strategies. Because it is a semi-structured interview, the responses are expected to be open-ended, and additional but related questions may be asked as part of probing or following up on what the participants may say. The interview should take between 20 minutes to an hour and be complimented with follow-up conversations and participant observation.

Freelisting activity

1. Can you list the types of changes you have observed in your time in Nawairuku with the most noticeable as number 1? (Environmental and social) When did they happen?
2. Can you list these changes in order of the effect they have on you or others in the village?

Livelihood activities and current stresses affecting livelihood activities

1. What livelihood activities do you engage in (e.g. farming, animal husbandry, fishing, wage employment, etc.)?
2. How often do you do this (e.g. once a day, week, month, year)?
3. Where do you do this? [identify and mark places on the map]
4. What do you do with the product (e.g. personal use, share, sell)? If share, with who? If sell, how much do you make? What costs are involved in selling the product?
5. How long have you done this? How did you learn? Who taught you?
6. Will this activity/skill/knowledge continue to be passed on through coming generations?
7. Does anyone in the household engage in formal wage employment? Do they bring back money or food/goods? What is the return rate?

8. What are the best conditions (climatic and non-climatic – e.g. weather, market conditions, land tenure) for _____ (activity from above)? Why? Are you getting these conditions? Has anything changed? What have these changes mean for you?
9. Is there anything making _____ (activity from above) more difficult? How has this affected you? Has it affected others? Has it always been like this (document historic events and responses if relevant)?
10. How are you dealing with these problems? (adaptation strategies) Are they working?
11. Is there anything that has helped you make it easier? (e.g. distance/access to resources?)

Past stresses affecting livelihood activities

1. Has it always been like this (document historic events and responses if relevant)? In the past when this happened, what did you do? Did you change the way you did things over time? What is different about today? Why is it different?
2. Is there anything we can learn from the past?
3. Has this happened in any other communities? What did they do?

Potential future stresses affecting livelihood activities

1. If the mentioned conditions were to continue, what would you do?
2. What would the following mean for your life? Rising air temperature; variable river level; extreme weather events; unpredictable seasons;
3. Is there anything that could help you make it easier to deal with?

Additional comments

Appendix 3 Project initiation email communication

Subject: Climate change adapta/ on project
Date: Sunday, 2 April 2017 at 5:52:38 pm Australian Eastern Standard Time
From: Tristan Pearce (sent by tristanpearce@gmail.com <tristanpearce@gmail.com>)
To: skiniviliame@yahoo.com
CC: teresa rietberg, Renee Curren/ , Roger Kitson

Dear Capt Kiniviliame Salabogi
Village Development Chairman, Na Wairuku Nalawa Ra
cc Roko Tui Ra, Moses Nakoroi

My name is Dr. Tristan Pearce and I am a professor at the University of the Sunshine Coast, Queensland, Australia. **My research experKse is adaptaKon to climate change, parKcularly among remote Indigenous popula Kons.** I am Canadian and have worked on climate change adapta/ on together with Indigenous peoples in Canada for over 14 years and more recently in Tuvalu and Fiji. I am a member of the UNESCO Indigenous knowledge and climate change group and am pleased that Fiji holds the presidency for the COP23.

I have been working with coastal villages in Nadroga-Navosa for the past two years in partnership with the Marine Ins/ tute at USP, learning how they are experiencing and responding to environmental changes. This involves working with people to understand what aspects of the environment and climate condi/ ons are important to their livelihoods, how these condi/ ons may be changing, how they are dealing with these changes, and what things make it easier or more difficult to cope. Ul/ mately, this informa/ on will be wri_ en into a report together with local people, that can then be shared with the Fijian Government and Interna/ onal community at the climate nego/ a/ ons (COP23) to bring a_ en/ on to the knowledge and experiences Fijians have of the local environment. This informa/ on is very important for when the interna/ onal community makes decisions on greenhouse gas emission reduc/ ons and adapta/ on financing.

It has been brought to my a_ en/ on that people living in Na Wairuku are also already experiencing changing environmental condi/ ons and have important stories to share. I would like to visit you in Na Wairuku to discuss the possibility of working together. I will be in Fiji between April 14-25 together with my colleagues, Renee Curren/ and Roger Kitson and we would like to visit you together with Teresa and Danielle Rietberg.

It would be an honour if you are suppor/ ve of this visit.

Sincerely,

Dr. Tristan Pearce

--
Dr. Tristan Pearce
Senior Research Fellow, Geography
Sustainability Research Centre, Faculty of Arts and Business
University of the Sunshine Coast, Queensland, Australia
Tel: +61 7 5456 5811 | Fax: +61 7 5456 5008 | Email: tpearce@usc.edu.au | www.usc.edu.au | www.envchange.com

Adjunct Faculty
Department of Geography, University of Guelph
Guelph, Ontario, Canada N1G 2W1

Subject: Fw: Climate change adaptation project
Date: Monday, 10 April 2017 at 1:04:54 pm Australian Eastern Standard Time
From: salabogi kiniviliame
To: Teresa Rietberg, Renee Currenti, Roger Kitson, Tristan Pearce

On Monday, April 10, 2017 2:59 PM, salabogi kiniviliame <skiniviliame@yahoo.com> wrote:

Hello sir , I apologize fpr the delay in responding to your mail, this is due to my commitments and the unavailability of internet in the village, I personally thank you for your commitments and dedication to the project, I as the Development Chairman of the Village I welcome the initiative that was mentioned and I already raise the issue to our monthly village meeting which was held last week in the village, and the whole village are awaiting your arrival, accommodation and other necessities for your stay will be provided by me, without any costs.Please don't hesitate to call or text or mail me: Phone contact is 9497280/9519016 (679) country code.

Looking forward that you will info me in advance once you coming is finalised.

Klni
Chairman Village Development Committee

Appendix 3 Project initiation email communication continued

Subject: Nawairuku visit

Date: Tuesday, 18 April 2017 at 12:42:33 pm Australian Eastern Standard Time

From: salabogi kiniviliame

To: Tristan Pearce, Renee Currenti, Roger Kitson, Teresa Rietberg

Team, thanking you for the dedication of time resources and a big effort in trying to send a quality message to the people of Nawairuku, I already spoke to the Senior Agricultural Officer of our Province and he welcomed the decision already planned for us to work together in June especially in using the drone to map the farmer location including the different commodities that they plant in their various villages . this will enhance the statistics required in the m Agriculture department.

Once again thanks and wishing you well in your journey, please send the message to Mathew and Danny

Kini

Appendix 4 USC Ethics Approval

23 March 2017

Dr Mark Sayers
Chair, Human Research Ethics Committee
Tel: +61 7 5459 4574
Email: humanethics@usc.edu.au

F25142

Dr Tristan Pearce
Dr Javier Leon
University of the Sunshine Coast

Dear Tristan and Javier

Expedited ethics approval for amended research project: Adaptation to Climate Change in Pacific Island Countries (A/15/751)

This letter is to confirm that on 22 March 2017, as the Chairperson of the Human Research Ethics Committee of the University of the Sunshine Coast I granted expedited ethics approval for an amendment to the above project.

The amendment refers to the addition of three new research team members.

The conditions for ethics approval for this project as outlined in our original letter of approval continue to apply.

If you have any queries in relation to this ethics approval or if you require further information please contact a Research Ethics Officer by email at humanethics@usc.edu.au or by telephone on +61 7 5459 4574 or 5430 2823.

Yours sincerely

Dr Mark Sayers
Chair, Human Research Ethics Committee

Appendix 5 USP Ethics Clearance

USP
OFFICE OF THE DEPUTY VICE-CHANCELLOR
Research, Innovation and International

The University of the South Pacific
Private Mail Bag, Laucala Campus
Suva, Fiji

Ph: (679) 323 2397
Fax: (679) 323 1504
www.research.usp.fj

Our Ref: Dr Tristan Pearce/2017/

To: Dr Tristan Pearce
Institute of Marine Resources

Date: 10 April, 2017

Re: Human Ethics Application

Dear Dr Pearce

The human ethics application for the following research project has been approved by the University Research Office.

Title: Adaption to Climate Change in Fiji.

Principal Researcher: Dr Tristan Pearce

The ethical values and principles apply to all University activities, to all its staff and student researchers including those visiting for short periods, and to any research agreements or partnerships that the University establishes. The University's human ethics will be compliant with the laws of individual University member states, particularly in relation to privacy, confidentiality, ownership, intellectual property requirements, research permit requirements and human rights.

All research conducted by persons affiliated with the University of the South Pacific will be carried out only with the prior, free, and informed consent of all persons concerned, whether individuals or communities, based on adequate information. The consent may be withdrawn by a particular individual or community at any time for any reason without disadvantage or prejudice.

Appendix 5 continued USP Ethics Clearance

Where research involving human subjects/participants is proposed by a researcher at the University of the South Pacific, agreement must be obtained from a fraction of those subjects or their spokespersons in advance of the proposal being submitted to the University Research Ethics Committee, who will require written evidence of such an agreement. Where appropriate, this must be translated into a language that is readily comprehended by potential participants. The rights of participants must be emphasized, their questions all satisfactorily answered.

Please note that it is the researcher's responsibility to submit relevant application forms for Research permit purposes. These must be submitted as annexes with the first progress report form. Also, be reminded that progress reports are expected at end of six-month period throughout the duration of the project.

Congratulations and all the best for your research project!

Director of Research
Research Office
Office of the DVC (Research & International)
The University of the South Pacific

Professor Derrick Armstrong

Deputy Vice Chancellor Research and International

The University of the South Pacific

Laucala Campus, Suva.

Fiji Islands.

Appendix 6 Consent Form

CONSENT TO PARTICIPATE IN RESEARCH

Adaptation to Climate Change in the South Pacific Islands: A case study of Nawairuku Village, Ra, Fiji
(Ethics approval numbers. USC: A/15/751. USP: Dr Tristan Pearce/2017/).

I have read and understand the Research Project Information Sheet for the above research project.
I realise this research project will be carried out as described in the Research Project Information Sheet.
Any questions I have about this research project and my participation in it have been answered to my satisfaction.

I agree to participate in the research project, *Adaptation to Climate Change in the South Pacific Islands: A case study of Nawairuku Village, Ra, Fiji*.
I give consent for my data about my participation to be used in a confidential manner for the purpose of this research project and future research projects.

You can use my name in connection with this project	YES ☐	NO ☐
I give my permission for audio recording	YES ☐	NO ☐
The audio recording can be stored securely in the village	YES ☐	NO ☐

_____ _____
Participant *Date*

_____ _____
Researcher *Date*

Appendix 7 Research Project Support Letter – USP

USP
FACULTY OF SCIENCE TECHNOLOGY AND ENVIRONMENT
Institute of Marine Resources
The University of the South Pacific
Laucala Campus, Private Mail Bag,
Suva, Fiji.

Ph: (679) 323 2995
Fax: (679) 323 1531
Email: Jeremy.Hills@usp.ac.fj
www.usp.ac.fj

Date: 16/03/2017

Fiji Department of Immigration,
Suva.

Re: Support For Research Project "Adaptation to Environmental Change in Fiji"

On behalf of The University of the South Pacific (USP), we are pleased to endorse the research project "Adaptation to Environmental Change in Fiji" led by Dr. Tristan Pearce and Dr. Javier Leon, and supported by Renee Currenti, Roger Kitson, Mikayla Cover and Mathew Brown from the University of the Sunshine Coast, Queensland, Australia. **In-country support** for this project is provided by The University of the South Pacific (USP; contact person Dr. Jeremy Hills, Director Institute of Marine Resources).

The **research** is formulated to be relevant to the people of Fiji in terms of maintaining ecological services and benefits form the natural resources of the region in a changing climate. The research will involve working with local people to document how they are experiencing and responding to environmental changes, and identify opportunities to support sustainable adaptation. The research intends to contribute to the development of more productive, equitable adaptation decision-making that better reflects and supports the needs, concerns and livelihoods of local people. The research is particularly relevant to the people of Fiji during the Fijian Presidency of the Conference of the Parties (COP23) – International climate change negotiations.

Yours Sincerely,

Dr Jeremy Hills
Director, Institute of Marine Resources,
The University of the South Pacific

Appendix 8 Research Project Support Letter – Nadroga-Navosa Provincial Council

PROVINCIAL COUNCIL
NADROGA/NAVOSA

NADROGA/NAVOSA PROVINCIAL COUNCIL
P.O. Box 267, Sigatoka, Fiji. **Phone:** 650 0004/6500137
Fax No. 6500 005/6500203**E-mail:nadroganavosapcoffice@gmail.com**

12/04/17

TO WHOM IT MAY CONCERN

Dear Sir/ Madam,

Re: Support for Research Project "Adaptation to Climate Change in Fiji"

On behalf of Nadroga Navosa Provincial Council, we are pleased to endorse the research project "Adaptation to Climate Change in Fiji" led by Dr. Tristan Pearce and Dr. Javier Leon, and supported by Renee Currenti, Roger Kitson, Mikayla Cover and Matthew Brown from the University of the Sunshine Coast, Queensland, Australia. In-country support for this project is provided by The University of the South Pacific (USP; contact person Dr. Jeremy Hills, Director Institute of Marine Resources).

The research is formulated to be relevant to the people of Fiji in terms of maintaining ecological services and benefits form the natural resources of the region in a changing climate. The research will involve working with local people within the Nadroga Navosa province to document how they are experiencing and responding to environmental changes, and identify opportunities to support sustainable adaptation. The research will also use high resolution mapping to characterize the environment. The research intends to contribute to the development of more productive, equitable adaptation decision-making that better reflects and supports the needs, concerns and livelihoods of local people. The research is particularly relevant to the people of Fiji during the Fijian Presidency of the Conference of the Parties (COP23) – International climate change negotiations.

Yours Sincerely,

L. Manuel
For ROKO TUI NADROGA NAVOSA.

Appendix 9 Contribution of Authors

This thesis includes two drafted manuscripts that contribute to addressing my identified research gap, question and objections. Due to this structure, there is a level of redundancy between some chapters of the thesis and sections of the manuscripts.

The first manuscript is titled 'Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji'. This manuscript describes the research approach and methods used, and the findings of the research. The second manuscript is titled 'Preparing for, experiencing and responding to cyclones and floods in Nawairuku, Ra, Fiji'. This manuscript builds upon the first manuscript and focusses on how the village prepared for, experienced and responded to two recent extreme weather events, a cyclone and an extreme flood.

Both manuscripts are co-authored by Dr Tristan Pearce (University of the Sunshine Coast), Prof Roy Sidle (University of the Sunshine Coast), and Dr James Ford (University of Leeds). I was primarily responsible for data collection and analysis, and the preparation of the manuscript. Dr Pearce and Dr Ford offered guidance and insights early in the data collection process. In drafting the manuscript Dr Pearce provided me with significant feedback and guided me on important elements of the framing and content. Prof Sidle and Dr Ford provided me valuable feedback and guidance at various stages of the writing process. Teresia Silabogi, Kini Silabogi, Roger Kitson and Brendan Doran made significant contributions to the research and will be invited as co-authors for the purpose of publication post-thesis submission.

The first manuscript will be submitted to *Global Environmental Change* after going through reviews and edits from co-authors and local research partners in Fiji. The second manuscript will be submitted to *Disasters* following the same process. Responsibility for any issues, errors, or omissions in either manuscript or the thesis falls entirely on me.

Signature: _____
Renee Currenti

Signature: _____
Dr James Ford

Signature:
Dr Tristan Pearce

Signature:
Prof Roy Sidle