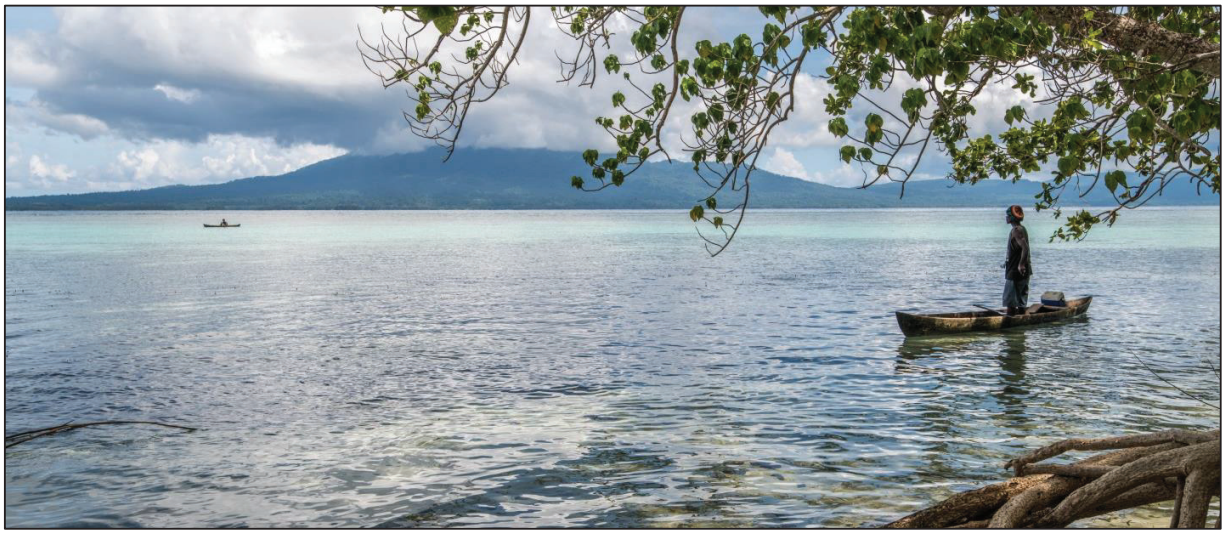
ZMT LEIBNIZ-ZENTRUM für Marine Tropenforschung

Universität Bremen

Livelihood Vulnerability of Coastal Communities in Fiji and Solomon Islands to Changes in Reef Resource Availability and Climate Change



By

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Thesis submitted in partial fulfillment
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Doctor of Philosophy in Political Science

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Contents

Declaration

I Akuila Cakacaka hereby declare that this PhD thesis has been composed and written solely by myself, unless where clearly stated otherwise. I have used only the sources, the data and the support that I have mentioned clearly. This thesis has not been submitted for conferral of degree elsewhere.

I confirm that no rights of third parties will be infringed by the publication of this thesis.

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Dedication

To the Lord Jesus my savior, my wife Paulini Cakacaka and son El-Nathan Malkijah Cakacaka for your everlasting support during my studies.

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Abstract

Fisheries support the livelihoods of millions of people globally. In the Pacific Islands most coastal communities have traditionally been highly dependent on marine resources. Coral reefs are particularly important to these communities as their main source of animal protein and livelihoods. Climate change and human-induced stresses have led to high mortality of coral reefs globally. These changes can lead to a decline in reef fisheries resources, thereby affecting the livelihoods of fisheries-dependent communities. The high dependence of coastal communities on marine resources potentially makes them highly vulnerable to any change in the status of these resources.

This research examined the livelihood vulnerability of coastal communities in Fiji and Solomon Islands to a decrease in reef resources resulting from social-ecological changes and the capacity of households and communities to cope with or adapt to these changes. Data from household interviews, key informant interviews and focus group discussions were collected using mixed methods from ten communities in Fiji and nine in the Solomon Islands.

Results of the interviews and focus group discussions were used to elucidate proximate and distal drivers of reef resource use in Fiji and Solomon Islands. The only proximate driver was access to new fishing gear and adoption of new fishing methods; while distal drivers included (1) requirements for food and income, (2) increase in population, (3) access to markets, (4) the need for monetary incomes to meet cultural and religious obligations, and (5) the importance of fishing as a way of life. These drivers maintain and increase fishing pressure on reef resources, interacting in sometimes complex ways that vary between the two countries and among communities.

Livelihood vulnerability was measured as a composite index, combining indices of exposure, sensitivity and adaptive capacity. Exposure relates to the condition of local reef resources, and was calculated based on fishers' perceptions of the current condition of reefs and the likelihood of future coral bleaching under climate change scenarios. Sensitivity relates to the degree of dependency on these resources and the availability of alternative sources of income. Adaptive capacity was calculated based on access by households and communities to physical, natural, financial, human and social assets, as defined by the sustainable livelihoods framework.

Results highlight the contextual nature of livelihood vulnerability in the studied communities in Fiji and Solomon Islands. Aggregate scores for vulnerability to decreasing reef resources were determined primarily by exposure, and secondly by adaptive capacity. Most households and communities had access to other sources of income, in addition to fisheries. This was reflected in low scores for sensitivity, since households that have access to alternative livelihoods can be expected to be less affected by decreasing reef resources. However they would still experience impacts from decreasing reef resources and climate change, since fishing is still important for their livelihoods as a source of protein, as well as culturally and as a 'way of life'. There was a

high degree of heterogeneity in the livelihood vulnerability between countries, among communities in each country and among households within individual communities, although differences are not always apparent from a simple comparison of aggregate index scores.

Scores for adaptive capacity did not vary greatly between the two countries or among communities but, again, these similar aggregate scores masked considerable differences in the distribution of assets among communities. For example, several communities with good access to physical assets (i.e. infrastructure and material possessions) possessed few human and social assets, and vice versa. Farming was one of the main adaptation options for fishing communities, as an alternative livelihood if reef resources continue to decline. However results highlighted that the availability of alternative livelihoods is not a sufficient measure of capacity to leave fishery in the face of declining reef resources. The capacity and willingness of households to exit a declining fishery in the studied communities was influenced by the interaction of site-specific bio-physical, economic, cultural and social factors.

This study also examined the impacts of tropical cyclone Winston, which struck communities in Fiji while the fieldwork was being undertaken. The cyclone devastated infrastructure and agricultural systems in communities that, using the vulnerability index applied in this study, would be considered relatively resilient to declining reef resources. This shows the danger of 'maladaptation', where actions taken to avoid or reduce vulnerability to climate change impact adversely on, or increase the vulnerability of other systems, sectors or social groups. Moreover, adaptation options that work today may not be effective in the future.

The results of this livelihood vulnerability assessment of households and communities will assist decision makers in devising policies and measures to build adaptive capacity in fishing communities threatened by declining reef resources. In the short term, improved management and governance of reef resources in Fiji and Solomon Islands, particularly through the implementation of *tabu* areas (i.e. areas closed to fisheries) can mitigate declines in reef resources caused by overfishing. However, in the longer term, climate change poses an existential threat to coral reefs and marine resources and well as other livelihood resources such as crops for communities in Fiji and Solomon Islands.

Future coral bleaching events are expected to have a devastating effect on coral reefs in the region. However, the timing and extent of these events remain uncertain and possible mitigation measures may still be identified. Thus it makes sense to do everything possible to maintain the health of coral reefs and their fisheries, while 'preparing for the worst' by diversifying into alternative livelihoods, including—but not exclusively—agriculture. Increasing adaptive capacity is essential both to enable households and communities to cope with shocks when they occur, and to facilitate the adoption of alternative livelihoods that are less dependent on climate-vulnerable resources.

Acronyms

CMT Customary Marine Tenure

CPI Consumer Price Index

DFID Department for International Development

EEZ Economic Exclusive Zones

FAD Fish Aggregating Device

FAO Food and agriculture organization of the United Nations

FGD Focus Group Discussion

Fi abbreviation use to refer to local study sites in Fiji

GDP Gross Domestic Product

GLM Generalized Linear Model

HHS Household survey

IPCC Intergovernmental Panel on Climate Change

KII Key Informants Interview

LMMA Locally Managed Marine Area

MPA Marine Protected Area

MSL Material Style of Life

NCFR Native Customary Fishing Rights

NLFC Native Lands and Fisheries Commission (now known as TLFC – iTaukei Lands and Fisheries Commission)

NTA No-take Area

SPC Pacific Community (formerly Secretariat of the Pacific Community)

PAFCO Pacific Fishing Company

PCA Principle Component Analysis

PICT Pacific Island Country and Territory

PNG Papua New Guinea

PHC Periodically Harvested (Fishery) Closure

RCF Roviana Conservation Foundation

SLF Sustainable Livelihood Framework

TDA Tetepare Descendants Association

UNEP United Nations Environment Program

USP University of the South Pacific

List of Tables

List of Figures

1 Chapter 1 Introduction

1.1 Context of the study

Coral reefs are one of the most productive and biologically rich ecosystems on earth (McAllister, 1995). They are complex dynamic ecosystems with interrelated processes between the physical, chemical and biological components as well as the social, economic and cultural services that humans depend on for health and economic growth (Mangi *et al.,* 2007). Not only are they a critical habitat for numerous species, but they also provide essential ecosystem services upon which millions of people depend (Burke *et al.,* 2011). These ecosystem services include: fisheries production, reef tourism and recreational activities, buffering from extreme weather conditions such as natural disasters, protection from coastal erosion and also cultural values (Moberg & Folke, 1999; Brander *et al*, 2007).

From a broader perspective, coral reefs provide revenue in many countries through the sale of reef resources but also through tourism and the recreational activities that they provide. Both reef fisheries and reef-related tourism are dependent on the condition of the reefs, which are presently under heavy pressure in many parts of the world (Beukering *et al.,* 2007). According to FAO (2014), there has been an increase in the annual growth of fish production globally, surpassing the annual growth rate of the world population. Nonetheless, there is a high demand for marine based resources around the globe (FAO, 2016).

1.2 Coral reef-based livelihoods of coastal communities

Coral reefs are recognized as dynamic and complex ecosystems and have a very high value for humankind (Nystrom *et al.*, 2000; Cesar *et al.*, 2003). Fisheries make a major contribution to national economies (Andrew *et al.,* 2007). Fish provides more than 2.9 billion people with almost 20 percent of their average per capita intake of animal protein, and 4.3 billion people with about 15 percent of such protein (FAO, 2014). The FAO estimates the maximum potential fish production from current marine fisheries to be around 80 million tonnes per year (FAO, 2016). Globally, millions of people in coastal communities are directly dependent on fishing and fish products for their livelihoods, and also depend on protein-rich seafood as the basis for their food security (Allison & Ellis, 2001; Allison *et al.,* 2009).

Coral reef fisheries account for only a small fraction (2-5%) of the global fisheries catches (Pauly *et al.*, 2003). The global importance of the coral reef fisheries lies in their contribution to the protein and income needs of poor coastal communities in the developing world (Sadovy, 2005). Thousands of coastal communities are dependent on coral reef fisheries for livelihoods and incomes (Cesar, *et al.,*1997). Reef fisheries typically tend to be small-scale, artisanal and/or

subsistence in nature, and occur in rural, poor and remote places away from regulated landing sites (Teh *et al.,* 2013). Artisanal or small scale fishers are "traditional fishers involving fishing households using relatively small amounts of capital and energy, relatively small fishing vessels if any making short trips close to shore" (FAO, 2005:1) Artisanal fishers also include subsistence fishers; however most coastal subsistence fishers also sell part of their catch (J. Johnson, 2005). Despite the artisanal nature of coral reef fisheries, they are estimated to generate more than US$5.7 billion annually, distributed across almost 100 countries (Teh, *et al.,* 2013).

The expansion of both the fishing industries and artisanal fishing have prompted fears of a worldwide crisis in fisheries (McGoodwin, 1990). The global increase in fishing effort has resulted in the overexploitation of certain species and decrease in fish stocks in many parts of the world (Pauly *et al*., 2002). The high dependence of people on coastal ecosystems has contributed to their degradation and overexploitation at a much faster rate than the terrestrial ecosystem (Jackson *et al.,* 2001). In the poorest countries in Africa and South Asia, 400 million people depend on subsistence and artisanal fisheries for their protein and mineral intake (Dulvy and Allison, 2009). In the Philippines, reef fishes are estimated to constitute 15-30% of fish sold at municipal markets and 55% of reef fish are consumed locally (Alino *et al*., 2004). A study in Indonesia revealed that more than 35% of the catch from artisanal or small-scale fishermen came from coral reefs (Cesar *et al.*, 1997). Rural coastal communities in most Pacific Island countries and territories rely on reef fish for 50-90% of animal protein (Johannes, 1981, Bell *et al.,* 2009). Fishing is a direct form of human dependence as well as a significant stressor on the coral reefs. Socio-economic drivers such as market access, poverty, lack of appropriate institutions and population growth drive overfishing of coral reefs (Cinner & McClanahan, 2006; Kronen *et al.,* 2010; Brewer *et al.,* 2012; Kittinger *et al.,* 2012). Overfishing and destructive fishing are among the most destructive human activities affecting coral reef ecosystems (McClanahan, 2002; Burke *et al.,* 2011)

Overexploitation of fishery resources through overfishing was evident in the collapse of the Canadian cod fishery in 1992 which caused major hardship in the Newfoundland coastal communities that depended on this fishery for their livelihoods (Woodrow, 1998; Schrank, 2005). Allison & Ellis (2001:933) made a strong statement that 'if one of the world's largest fisheries, exploited continuously for the last 500 years, could not be sustained by a nation with advanced research, monitoring and management capacity, it left little hope for success elsewhere'. Some overharvested fish populations even fail to recover after considerable reduction in fishing pressure (Hutchings & Reynolds, 2004). Walsh *et al.,* (2006) found that selective harvesting of large fish (as in most fisheries) resulted in substantial declines in fecundity, egg volume, larval size at hatch, larval viability and larval growth rates.

Coral reefs are losing their resilience and undergoing phase shifts to alternate states as they become vulnerable to anthropogenic and climate change (Folke *et al.,* 2004; Hughes *et al*., 2007; Hughes *et al.,* 2010). Studies have shown that large-scale ecological changes associated with climate change, pollution and increasing fishing effort (McClanahan, 2002; Pandolfi *et al.,* 2011)

could shift coral reefs to an undesirable macro-algal dominated state (Mumby *et al.,* 2006; Mumby, 2009). These changes affect fish habitat, productivity and distribution, and directly impact fishing operations and the physical infrastructure of coastal communities (Sumaila, *et al.,* 2011). Therefore, important ecosystem goods and services provided by corals reefs could be altered through changes in species composition potentially reducing reef fisheries productivity and consequently compromising the livelihoods of reef-dependent people (Moberg & Folke, 1999; Cinner *et al.,* 2012). The evaluation of links between social and ecological dimensions of vulnerability to overexploitation of reef resources and climate change is a priority and can help to reduce difficult-to-reverse impacts on coral reefs and increase food security (Hughes *et al.,* 2003; Hughes *et al.,* 2012). The definitions and dimensions of vulnerability and livelihoods are discussed in Chapter 2. The impacts of climate change and interacting anthropogenic stressors in coral reefs will be felt predominantly by artisanal and small-scale fishers (Badjeck *et al.,* 2010). Artisanal fishers, who are mainly from developing countries, are highly susceptible to environmental change due to the limited spatial scale of their activities and other complex socio-economic, demographic, and policy trends that often limit their capacity to adapt (Morton, 2007). People that depend on coral reefs may need to adapt their resource-use patterns to maintain the flow of goods and services (Cinner *et al.,* 2013). The increase in overfishing has been associated with a high population growth; moreover fish demand per capita has increased annually (Merino *et al.,* 2012; FAO, 2014). It is predicted that coastal human populations will continue to increase, especially in coastal cities (Sekovski *et al.,* 2012). A recent study showed that a growing population with shrinking economic opportunities and access to land leads to an increase in both the number of people living in the coastal zone dependent on fishery resources, as well as the number of fishers (Pomeroy *et al.,* 2016). Pomeroy and colleagues highlight that fish scarcity is driven by a suite of different biological, social and governance factors. The increase in human population, improved storage and transport systems (Hughes *et al.,* 2003), market availability (Brewer *et al.,* 2012; Cinner *et al.,* 2013), and increased human impacts on reefs (such as pollution from agriculture and land development) are the main causes for widespread changes in reef ecosystems over the decades (Pandolfi *et al.*, 2003). These changes in reef ecosystems can be managed at a local scale but the compounding superimposed impacts of global climate change mean there is limited successful management of reef resources (Hughes *et al.,* 2003).

Global climate change and related coral bleaching pose a considerable threat to coral reefs. Global warming and ocean acidification will cause corals becoming increasingly rare on reefs and this has been exacerbated by human-induced stressors resulting in less diverse reef communities and a functional collapse (Nyström *et al.,* 2000; Hoegh-Guldberg *et al.,* 2007). The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report (IPCC, 2007), indicates that the average global land and ocean surface temperatures have warmed by 0.74°C over the last 100 years (1906-2005) and the rate of warming over the past 50 years (0.130°C per decade) is almost twice that of the past 100 years (0.070°C per decade). This warming has been associated with changes in global climate systems such as more intense rainfall, more frequent droughts, sea level rise, loss of Arctic sea ice, melting of land based ice

(IPCC, 2007) and widening of the tropical climate belt (Seidel *et al.,* 2008). These changes may also include the increase in frequency and intensity of hurricanes (tropical cyclones and typhoons) in some regions, which may lead to shorter recovery time of coral reefs between recurrences (IPCC, 2001). These extreme climate events may directly affect the livelihoods of fisheries dependent households in coastal communities (Coulthard, 2008; Iwasaki, *et al.*, 2009)

1.3 Coastal environments of the Pacific

The Pacific island region consists of 14 independent countries and 8 territories located in the western and central Pacific Ocean and encompasses a large region of international waters with atolls and high and low lying islands (Gillett, 2010). The South Pacific has one of the largest areas of coral reefs in the world, and a large number of coastal communities from the region depend directly on these marine resources for their livelihood (Johannes, 1981; Kronen, 2010). The vast Pacific Ocean is under threat from ocean acidification, natural disasters, marine pollution and overfishing (SPC, 2011; SPC, 2014).

The region has been historically divided into three sub-regions in recognition of its diversity – Melanesia, Micronesia and Polynesia. These divisions are not political but based on the physical nature of the islands, biogeography, ethnic origin, social and culture (Fig. 1.1). The Pacific region depends heavily on fisheries and aquaculture for economic development, government revenue and food security (Bell *et al.,* 2011, 2013).

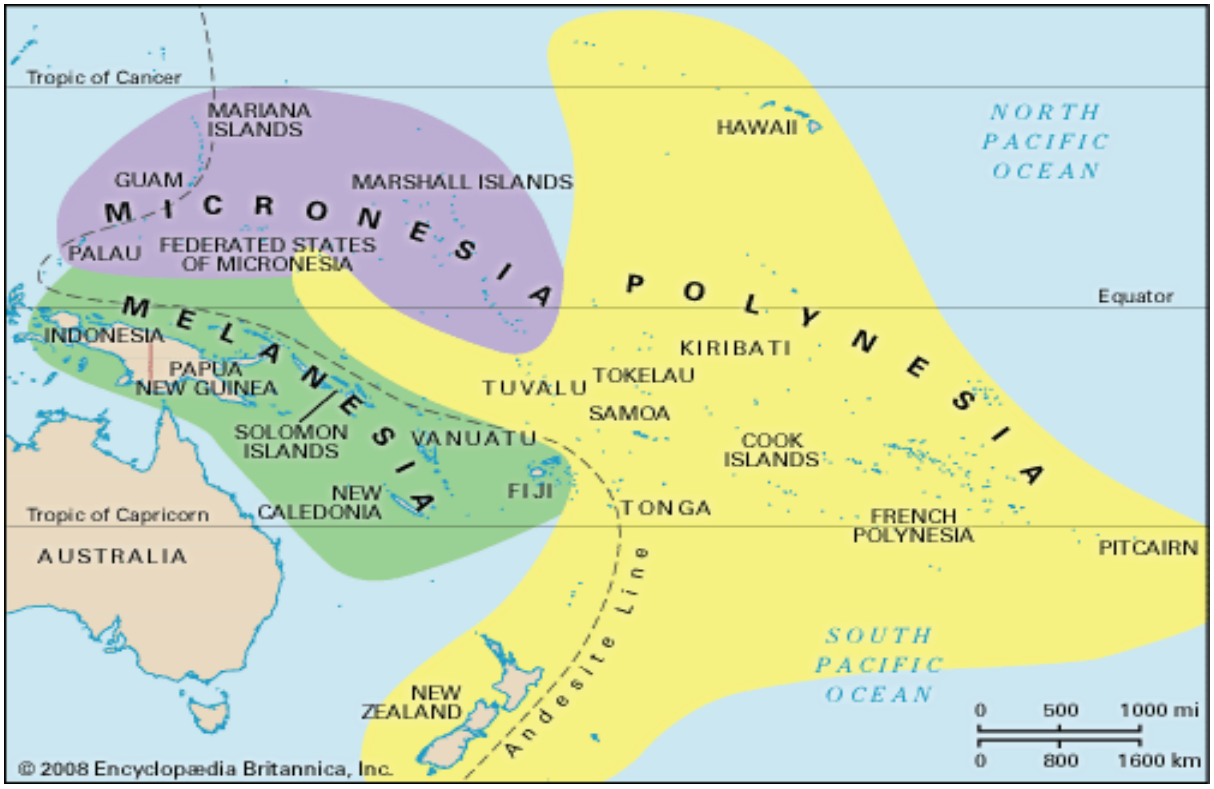

Figure 1.1: Map of the tropical South Pacific Islands region with the 3 divisions

(Source: Encyclopedia Britannica, 2008)

1.4 The Melanesian context

The Melanesian group of islands in the Pacific consists of Papua New Guinea, Solomon Islands, Fiji, Vanuatu and New Caledonia (French territory). The Melanesian people are culturally distinct from all other groups of people in the Pacific. Solomon Islanders, *Ni* Vanuatu and Papua New Guineans communicate using Pidgin English. The use of Pidgin English reflects the diversity of languages in these three countries. Fijians on the other hand speak English and the local Fijian and Hindi languages. Solomon Islands and Fiji have the second and third highest land masses in Melanesia respectively with large reef areas (Table 1.1) (SPC, 2008; Gillett, 2010). This doctoral research focuses mainly on coastal communities in Fiji and Solomon Islands. These two countries have the largest land masses in the Pacific, apart from Papua New Guinea, and their coastal communities depend heavily on reef resources for their livelihoods (Veitayaki, 1997). Fiji and Solomon Islands were selected to represent the Melanesian context.

Table 1.1: Table showing land mass, reef area, fish consumption, population and population annual growth rate for Solomon Islands and Fiji.

Country	Land Mass (km^2)	Reef Area (km^2)	Fish consumption (kg/person/year)	Population	Annual Growth Rate (%)
Solomon Islands	28 000	8 535	21	515 870 (2009)	2.5
Fiji	18 333	10 000	33	837 271 (2007)	0.5

Source: SPC-SDD population data sheet 2013 and Bell *et al.* 2011

1.5 Coastal reef fisheries in the Pacific

Much of the region's nutrition, welfare, culture, employment and recreation are based on the living resources in the zone between the shoreline and the outer reefs (Gillett, 2010). Most reef resources are extracted from areas between the shoreline and the outer reefs (Gillett, 2011). In coastal communities, the continuation of current lifestyles, opportunities for future development and food security are all dependent on coastal fishery resources. Although coastal fisheries are dwarfed by size and value by the offshore tuna fisheries in most countries (Table 1.2), the Pacific Island coastal communities are coastal fisheries-based. Coastal fisheries harvest a diverse range of finfish, invertebrates and algae. While most tuna is caught by foreign fishing vessels, coastal catch is taken by Pacific Islanders themselves with very little involvement of foreign vessels. Coastal fishers in the region are artisanal fishers and they contribute >1 percent of the global total of fisheries workers in the world (Teh *et al.,* 2013).

The smaller the scale of fishing the less is known about the production levels. Quantitative information is especially scarce for the subsistence fisheries in most Pacific Island countries (Gillett, 2010). Although most countries in the region attach great importance to their subsistence and small-scale fisheries; it is these fisheries that present the greatest difficulties for the collection of production information. Short-term support has been provided by the Food and Agricultural Organization (FAO), Secretariat of the Pacific Community (SPC) and other bilateral agencies for the collection of small scale fisheries data but once the support is withdrawn data collection becomes dysfunctional (Gillett, 2009). Despite the importance of data on coastal fisheries, the long-term routine collection of coastal fisheries data has not received much priority due to limited government funding (Gillett, 2011; Gillett, *et al.*, 2014).

Table 1.2: Marine fisheries production in Pacific Island countries, 2007 (tonnes)

Country	Coastal commercial fishing	Coastal subsistence fishing	Offshore locally based fishing	Offshore foreign based fishing	Total (tonnes)
Papua New Guinea	5 700	30 000	256 397	327 471	619 568
Kiribati	7 000	13 700	0	163 215	183 915
Federates States of Micronesia	2 800	9 800	16 222	143 315	172 137
Solomon Islands	***3 250***	***15 000***	***23 619***	***98 023***	***139 892***
Marshall Islands	950	2 800	63 569	12 727	80 046
Nauru	200	450	0	69 236	69 886
Fiji	***9 500***	***17 400***	***13 744***	***492***	***41 136***
Tuvalu	226	989	0	35 541	36 756
Vanuatu	538	2 830	0	12 858	16 226
Samoa	4 129	4 495	3 755	25	12 404
Tonga	3 700	2 800	1 119	0	7 619
Palau	865	1 250	3 030	1 464	6 609
Cook Islands	133	267	3 939	0	4 339
Niue	10	140	640	0	790

Source: ADB, 2009

A study by Dalzell & Schug (2002) reviewed the important finfish that are most caught by Pacific Island coastal fisheries. In their review they stated that typical small-scale fisheries in the western and central states of the region can harvest between 200 and 300 finfish species. From the 15 landings that they surveyed across the region, approximately one-third of the coastal catch was comprised of emperors (Lethrinidae), surgeonfish (Acanthuridae) and snappers (Lutjanidae).

1.6 Reef resource dependence in the Pacific

The Pacific Islands countries have one of the highest rates of consumption of seafood on Earth, and fresh fish dominates their diet (Bell *et al.,* 2009). A study conducted by SPC, (2008) showed that more than 60% and 90% of fishing households in Solomon Islands and Fiji respectively earn their first or second income from selling surplus[1] fish and invertebrates. With this high dependency and consumption rate of reef resources in the region, exploitation of these resources by coastal communities has been very high (Kronen *et al.,* 2012). This has also been driven by demographic changes, and economic trends at local and national levels including changes to the

[1] Fish and invertebrates that are more than what households can consume

consumer price index (CPI) and gross domestic product (GDP) (Kronen *et al.,* 2010). The high demand for reef products from local and urban markets has put pressure on the fishers and the reef resources (Bell *et al.,* 2009).

The Pacific coastal communities' high dependence on natural resources makes them highly vulnerable to any change in the conditions of the reef resources (Pomeroy *et al.,* 2006). The ecosystem goods and services provided by coral reefs can be greatly influenced by changes in both the natural environment and socio-economic systems, for example the changes in the availability of resources, the value of the resource and the means to exploit them (Turner *et al.*, 2007; Kittinger *et al.,* 2012; Norström *et al.*, 2016). If these coastal communities lack an alternative livelihood, then a decrease in natural resources will adversely affect them. Coral reefs are threatened by human activities and climate related events globally which in turn affects the lives of people who depend on coral reef resources for livelihoods (Pandolfi *et al.,* 2003; Burke *et al.,* 2011). A report by Gillett & Cartwright (2010) indicated that the key factors that drive change in Pacific Island fisheries include: population growth and urbanization; economic development; governance and political stability; climate change; limits to domestic fishery production; markets and trade; fuel costs; technology and innovation and foreign aid.

1.7 Customary marine tenure (CMT) systems in Melanesia

With most of the coastal communities in Melanesia depending on reef resources for their livelihoods, complex local institutions govern access to and the use of these resources. In Melanesian countries, reef resources are not a common property and not everyone has access. The Melanesian group is well known in the Pacific for diverse customary and traditional marine tenure systems (Johannes, 1978; Hviding, 1988) which regulate the access to reef resources (Hviding, 1998). In most cases the right to fish in a particular area is controlled by a clan, chief or larger communal group who regulate the exploitation of reef resources, and this has been practiced for centuries (Johannes, 1978; Wright and Hill, 1993; Veitayaki, 1997). Johannes (1978) reports that such regulations include closing of fishing grounds, seasonal closures, restrictions on the number of fish traps, ban of certain species, and size restrictions. Customary marine tenure (CMT) or sea tenure is defined as " systems of social relationships that involve participants and operators, in groups and as individuals and in different capacities, as rights-holders, decision-makers, insiders and outsiders and are generated, maintained, and transformed by social processes" (Ruddle *et al.,* 1992:252). The effectiveness of these marine tenure systems today depends mainly on the historical, socioeconomic, political and environmental conditions in which these resources are governed. In Melanesia, national laws protect indigenous land tenure and most of the land is customarily owned by communities (Clarke & Jupiter, 2010). The Fisheries Acts of Solomon and Fiji protect the rights of customary owners of fishing grounds (Fiji Fisheries Act; Review 1985 and Solomon Islands Fisheries Act 1998). The customary marine tenure systems were not recognized in the colonial period, which resulted in historical

conflict between the open access regimes that the western colonizing states introduced and the customary tenure which people used (Lam, 1998). In most parts of Melanesia and the Pacific, most activities in rural coastal areas are nowadays governed by both traditional and customary rules and formal laws (Caillaud *et al*., 2004; Care & Zorn, 2001). Customary tenure is still the principal tool for regulating the extraction of natural resource in Melanesia today (Cinner & McClanahan, 2006; Aswani *et al*. 2007; Cinner & Aswani, 2007; Bennett, 2012).

The idea of CMT is to protect users of reef resources (users are defined by birth, marriage and kinship ties) and grant them exclusive rights over their reef territories with the ability to exclude outsiders (Aswani, 2005). The degree to which a community can exercise its customary marine rights varies and is subject to the strength of the traditional governance, population pressure, commercialization of fishery and the governments' recognition (Aswani, 2002; Cinner, 2005). Even though some customary marine tenure systems in the Pacific have eroded due to processes such as demographic changes, urbanization, economic development, technological innovation, commoditization of fisheries and indigenous socio-cultural transformation (Aswani, 2005), CMT has been reinvigorated through improved environmental awareness of non-governmental organizations (NGOs), researchers and government institutions (Ruddle, 1998). CMT is more localized (Aswani, 2005) while the modern rights-based fisheries management is market-driven and highly regulated by governments (McCay, 1995).

Most of the regulations under the CMT systems were verbally passed on through generations (Asafu-Adjaye, 2000). CMT institutions are dynamic (Aswani, 2002) and the unwritten and uncodified nature of CMT has allowed flexibility in adapting to changing social, political, economic and ecological circumstances (Lam, 1998). Recent studies in the region have confirmed that communities that are closer to markets and able to sell their marine resources have weaker CMT than those that are further away (Cinner, 2005; Turner *et al.,* 2007; Clarke & Jupiter, 2010).

1.7.1 Customary marine tenure in Solomon Islands

Solomon Islands reef resources and nearshore reefs are governed by the local people using CMT systems and are controlled communally by kin-based groups (Hviding, 1988; Hviding, 1998). Customary leaders of kin groups or tribes are the custodians of the reef resources within their territory, and reef resource users can have access to these resources through kinship ties (Hviding, 1998). The boundaries of the marine areas that belong to a specific tribe are not clearly demarcated but ownership of reef and lagoon areas lies with the owners of the adjacent land (Aswani, 2002). According to Aswani (2005), CMT institutions in the Solomon islands have survived the changes that have been brought by the colonial and post-colonial governments of the 19th and 20th centuries. These two centuries witnessed the change from traditional rights-based institutions to common property fishery institutions around the globe (Ciriacy-Wantrup and Bishop, 1975).

In the Marovo lagoon of New Georgia, Hviding *et al.,* (1992) report that reef resources are entirely controlled by people with ancestral titles and by the groups that have an historical origin as coastal dwellers. They therefore own the reefs and the sea that they are entitled to. There is a continuous adaptation in the Marovo Lagoon of these customary marine laws through negotiations between individual fishermen and descent groups relating to who should have access to which areas. Aswani (2002) found that in the Roviana lagoon, the chiefs and elders control resource use and access entitlements upheld by customary law and sanctioned by the national statutory law. Section 12 of the Fisheries Act states that 'Commercial fishing in waters subject to customary fishing rights may be carried out subject to such rights' (Solomon Islands Fisheries Act, 1998:19). In Roviana, people can inherit entitlements from their parents so they can access reef resources from both their parents' fishing grounds. This can cause conflicts in certain communities especially when the resources in question have a high economic value (Aswani, 2005). Monitoring and enforcement of the CMT is conducted by local leaders who are selected by the chiefs of respective communities.

1.7.2 Customary marine tenure in Fiji

Customary marine tenure in Fiji still exists and inshore fishing grounds are managed through the CMT system (Matthews *et al.,* 1998). The Fiji Fisheries Act section 13 states that

> "…it shall be an offence for any person to take any fish on any reef or any kind of shellfish in any area in respect of which the rights of any *mataqali* (sub clans or land owning units) or other division or subdivision of the Fijian people who have been registered by the Native Lands and Fisheries Commission (NLFC) in the Register of Native Customary Fishing Rights (NCFR) unless he shall be a member of such *mataqali*, division or subdivision of the Fijian people who does not require a license under section 5 to take such fish or shall first obtain a permit from the Commissioner of the Division"
> (Fiji Islands Government: Fisheries Act, 1985: 8)

Fishing grounds in Fiji are referred to as '*iqoliqoli'* and are demarcated and mapped out specifically for particular districts or clans (Teh *et al.,* 2009). The Native Lands and Fisheries Commission office maintains maps which outline all *iqoliqoli* in Fiji. These maps assist traditional leaders in the decision-making processes concerning the use and management of reef resources in consultation with community members. While the state legally controls sea tenure, most decisions concerning the access and use of reef resources are made by the communities and endorsed by local chiefs of communities.

Residents that are not part of the district or community and want to access these fishing grounds need to obtain a license from the Department of Fisheries upon receiving the approval of the respective owners of the fishing ground that one wishes to fish in (Teh *et al.,* 2009). Any fisher

who wishes to fish in any customary fishing ground in Fiji who is not a registered under the NCFR has to obtain a fishing license from the Department of Fisheries. Customary owners of a fishing ground do not require a fishing license if they are fishing only for subsistence use, but a license is required if they wish to sell their catch.

In the district of Kubulau in Fiji, the traditional and customary laws state that the custodians of the resources and the Fisheries Department need to be involved in granting of fishing licenses to anyone that wants to fish in their fishing ground (Clarke & Jupiter, 2010). This district in Fiji only gives out fishing licenses to individuals that have access rights so that they can sell their catch. Fishing licenses are not issued to anyone from outside the district. In other areas in Fiji, fishing licenses can be given to anyone with the approval of the customary owners of the respective fishing ground and the Fisheries Department. To integrate customary laws and the national laws, local fish wardens have been introduced in most coastal villages in Fiji. The fish wardens' basic role is to monitor and enforce customary and national inshore fisheries laws at the community level.

1.8 Threats to reef resources

In Melanesian communities with weak CMT, there is a growing concern that the exploitation of reef resources will increase. There is a wide concern amongst researchers and local communities today that there is significant decrease in the abundance of reef resources in the region (Johannes, 1978; Bell *et al.,* 2009; Brewer *et al*. 2009; Bartlett *et al.,* 2009; Gillett & Cartwright, 2010; Kronen *et al.,* 2010). Researchers have tried to identify the factors that have caused the decrease in reef resources in Melanesia. A report by UNEP-WCMC (2015) stated that the key threats to coral reefs in Fiji originate from: overfishing, sedimentation, destructive fishing methods, cyclones, and coral bleaching; while threats in the Solomon Islands include: high population growth, mining of coral for lime, logging and coral bleaching.

1.8.1 Human activities

There is overwhelming evidence that human activities are one of the main causes of change in marine ecosystems globally (Hughes, 1994; Pandolfi *et al.,* 2003). Most fishers in coastal communities of Melanesia are either subsistence fishers or artisanal fishers or both (Veitayaki, 1997; Teh *et al.,* 2009). Subsistence and artisanal fishers can have great impacts on the reefs as found by Jennings and Polunin (1996): even a removal of 5% of fish biomass annually from the reefs can cause significant changes in reef fish communities. Human induced environmental factors play a crucial role in changing the coral reef system (Graham *et al.*, 2007). The biggest threat to coral reef diversity, structure, function and resilience is overexploitation by humans and this has caused changes and shifts in fish species (McClanahan, 2002; Dulvy *et al.,* 2004). Removal of top predators and herbivores by fishing can have detrimental cascading effects on

the coral reef structure and function and therefore reduce the productivity of the fisheries (Dulvy *et al.,* 2004; Mumby *et al.,* 2006).

In Fiji and Solomon Islands, night diving using spear guns led to the removal of top predators and functional groups (Hamilton *et al.*, 2012; Jupiter *et al.,* 2012). The catch comprises mostly herbivorous and carnivorous fishes which are the preferred fish for consumption in most Pacific island countries (Kronen *et al.,* 2012). The new technologies have reduced the biomass of reef fishes (Jennings and Polunin, 1996; Newton *et al.,* 2007; Guillemot *et al.,* 2014) and led to increased exploitation of groupers and parrotfishes, which illustrates a mismatch between the global demand for reef fishes and the fundamental role of functional groups in ecosystem resilience (Bellwood *et al.,* 2004). However, it is important to understand that other factors, such as land-based activities causing runoff of pollutants and nutrients into coastal waters, can also contribute significantly to the alteration or destruction of natural reef habitat (Halpern *et al*., 2008).

1.8.2 Availability of markets and cash economy

In 1978, Johannes commented that one of the causes for the decrease in reef resources was the introduction of markets and a cash economy. In the past, most fishers would share their catch with other households and members of the community if there was surplus. Nowadays, this surplus catch is sold, so there is a competition for money and a drive to fish more. Today increase in markets has become one of the main drivers of the high exploitation of reef resources within coastal communities in Melanesia (Kronen *et al.,* 2010; Brewer *et al.*, 2012; Jupiter *et al.*, 2012; Brewer, 2013). The increasing market price of fish has increased the intensity of fishing (Cleasby *et al*., 2014).

This is not only the case for local markets, but also due to developments on global markets which have been a significant driver in the harvesting of reef resources (Berkes *et al.,* 2006; Ferse *et al.,* 2012; Purcell *et al.,* 2013). The increase in market price for marine products could stem from a scarcity in reef resources as well as from an increase in demand from urban centres, the wider community and international markets. There has also been a shift in most countries in Melanesia from rural to urban centres and this has also led to increased demand for marine resources (Sabetian & Foale, 2006). The demand for live reef fish from China, Singapore and Taiwan, with a retail price of up to $US250 per kg, exerts additional fishing pressure on reefs throughout vast areas of the Indo-Pacific (Sadovy, 2002). These new markets have greatly augmented the intensity and scale of exploitation and are set to increase as fish stocks elsewhere continue to decline (Pauly *et al.*, 2002).

1.8.3 Increase in population

Human population growth in Melanesia has increased greatly and there has been a shift in population from rural to urban centres (Gillett & Cartwright, 2010). Population growth in Melanesia is higher than in Polynesia and Micronesia (Table 1.3). The annual population growth rate in Solomon Islands is higher than Fiji (Table 1.1) and it is predicted that the population of Solomon Islands will be pass the 900,000 mark by 2030. A recent study revealed that the populations of Fiji and Solomon Islands increased by 3.1% and 19.1%, respectively, between 2007-2014 (Gillett, 2016). The rapid growth in population in many Pacific Island countries and territories has demanded new approaches to the sustainable use of resources for economic , human and social development (Bell *et al.,* 2011).

Table 1.3: Population growth rates in Melanesia, Polynesia and Micronesia.

Pacific Region	Growth rate
Melanesia	2.1
Polynesia	0.2
Micronesia	1.6

Source: SPC-SDD population data sheet 2013

Rapid population growth in the region has been shown to have caused social cultural and economic changes and increased the exploitation of reef resources (Jennings and Polunin, 1996; Aswani, 2002; Dulvy *et al.,* 2004b; Bell *et al.,* 2009; Teh *et al.,* 2009; Gillett & Cartwright, 2010; Butler *et al.,* 2014). The increase in population and/or the greater market demand for fish has led people to invest in more sophisticated fishing gear, which can further exert pressure on reef resources (Jennings and Polunin, 1996a, 1996b; Jupiter *et al.,* 2012). The real challenge to sustainability of coastal fisheries will rise as food requirements increase by 20-60% over the next two decades (Bell *et al.*, 2009), and more people will seek to earn their livelihoods from fisheries (Gillett & Cartwright, 2010). The increasing population experienced by coastal communities in Fiji and Solomon Islands could have a substantial impact on reef resources.

1.8.4 Climate change

Climate change is defined as "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2007:27). Humans and the natural ecosystems that provide goods and services have failed to adequately cope with prevailing climatic condition. Climate impacts humans and nature through increasing air and sea water temperatures, changes in sea water chemistry causing ocean acidification, changes in seasonality, and increased frequency and severity of storms, amongst other effects (IPCC, 2007). These changes have been widely recognized to be caused by gas emissions from human activities (Zickfeld *et al.*, 2017). Climate change is directly affecting the living conditions of most people in developing countries

through increasing variability and uncertainty of the conditions in which people try to pursue their livelihoods (IPCC, 2007).

Climate change is a key threat to coral reefs and the marine fisheries in general (Hughes *et al.,* 2003; Allison *et al.,* 2009). Coral bleaching and coral mortality due to increasing seawater temperature has been recorded as one of the most significant impacts of climate change on the marine realm (Hughes *et al.,* 2003; Hoegh-Guldberg *et al.,* 2007; Cinner *et al.,* 2012). Coral bleaching in the Western Indian ocean in 1998 caused widespread coral mortality (Graham *et al*., 2007; Pratchett *et al., 2*008). In Fiji and Solomon Islands, the El Nino of 1998 and La Nina in 2000 caused mass coral bleaching in most reefs (Cumming *et al.,* 2000).

Natural disasters such as tropical cyclones are the most destructive weather disturbances that affect most parts of the Pacific (Emanuel, 2003). Tropical cyclones bring strong winds, high rainfall, storm waves and destructive storm surges and occur in the region from Category 1 through to the most severe, Category 5 (Bell *et al.,* 2011). In 2010, there were two cyclones that struck Fiji and Solomon Islands at the same time (cyclone *Tomas* in Fiji and cyclone *Ului* in Solomon Islands) (UNICEF Report, 2010). In 2015, cyclone Pam affected remote islands in Vanuatu (Magee, *et al.*, 2016). Most cyclones affect infrastructure in human settlements, with direct loss of human life, livestock, farms and indirect losses through impacts on coastal ecosystems such as coral reefs, sea grass beds and mangroves (Lugo *et al.,* 2000; Pielke Jr *et al*., 2003). Economically cyclones can incur damages that could cost governments, communities and people substantial amounts of money. Hurricane Mitch that stalled over Honduras and Nicaragua in October 1998 caused US$8.5 billion in damages (World Disaster Report, 2000). A Category 5 cyclone which hit Fiji in February 2016 recorded an estimated US$0.9 billion in damage and losses, equivalent to about one fifth of the country's 2014 GDP (Esler, 2016).

1.9 The Tuna industry in the Pacific

Tuna fisheries have been important in the Pacific Island countries and territories (PICTs) for centuries but prior to 1900 this activity was small-scale, using paddle out canoes just outside the reef (Gillet, 2007). The tuna fishery has grown substantially over the past decades, and tuna fisheries are now important to many small island nations in the Pacific (Bell *et al.,* 2011). The key benefits of tuna fisheries to the Pacific Island countries are economic development, government revenue, significant contributions to food security, and employment (Bell *et al.,* 2011). Tuna fisheries produce about ten times more of fish, with a value seven times greater, than all the other fisheries (inshore fisheries and aquaculture) in the region combined (Gillet *et al.,* 2001). In five Pacific Island countries and territories the license fees associated with access for distant water fishing nations to harvest tuna from their economic exclusive zones (EEZs) provide between 10% and 42% of all government revenue (Gillet *et al.*, 2001).

The main countries that have access to tuna fishery in the Pacific EEZ waters include Japan, USA, Republic of Korea, Taiwan and China, amongst others (Gillet, 2007). The main species that dominate the catch are skipjack, yellowfin, bigeye tuna and the South Pacific albacore. Together these represent 90% of their catch (Bell *et al.,* 2011). The remainder of the catch is comprised of billfish (marlin and swordfish), oceanic sharks and Pacific Bluefin tuna. The use of fish aggregating devices (FADs) has assisted in the capture of these species. Small-scale artisanal fisheries have benefitted from FADs that have been positioned near reefs through the use of trawling gear to catch skipjack, yellowfin and other pelagic and reef fish (Bell *et al.,* 2011). Another method used by fishing vessels to catch matured bigeye and yellowfin tuna in the equatorial waters for the sashimi trade and high-value markets is longline. The gear used by foreign vessels could reduce the accessibility and availability of pelagic fish species for coastal communities.

Currently, fish consumption in the PICTs is based mainly on small-scale subsistence from coral reefs (Bell *et al.,* 2009); the production of fish from coral reefs will not yield the recommended 35kg of fish per person per year or continue to supply the traditionally higher quantities of fish as the human population grows (Bell *et al.,* 2015). Tuna is also a major part of the diet for both rural and urban communities in many PICTs (Bell *et al.,* 2009; Gillet, 2009) but tuna fishing has been commercialized, where licenses are given to foreign vessels to fish this commodity. Recent assessments on the stock of skipjack, yellowfin and albacore showed that its exploitation is still at a moderate level (Hoyle *et al.,* 2010) while bigeye tuna has been overfished (Harley 2010). The decrease in coral reef fish in most PICTs encourages the shift to catching pelagic fish species such as tuna (Bell *et al.,* 2015). While it is appealing that policies and natural resource management strategies should aim to substitute the decreasing coral reef fish with increased domestic supply of tuna, this would require profound structural changes to tuna value chains (Albert *et al.,* 2014). This would include changes in landing a greater proportion of commercial catch at regional ports and changes in the processing and marketing of tuna (Bell *et al.,* 2015).

Tuna are highly migratory; therefore communities are faced with considerable challenges in catching them. Nearshore FADs have been proven to improve the local access of PICT communities in catching pelagic fish species such as tuna (Albert *et al.*, 2014). Nearshore FADs are floating objects that attract tuna and other pelagic species, which stay within their vicinity for several days (Bell *et al.,* 2015). Local communities in the Pacific Islands benefit from FADs through; 1) increased fishery production; 2) reduced pressure on reef resources; 3) reduced fuel consumption; 4) safety at sea and 5) maintained fishing interest (Sharp, 2011). A study by Albert *et al.* (2015) in the Solomon Islands showed that fishing at FADs increases income and consumption of fish. FADs are an important source of fish for community fundraising and feasts. However FADs can also lead to the overexploitation of a resource.

With the different factors threatening reefs in Melanesia, and undesirable levels and patterns of resource exploitation, there should be measures taken to control this exploitation. The threats observed in the region will exacerbate the decline of marine resources that coastal communities

are experiencing. Effective management is required at different levels for these threats to be mitigated, considering the number of people that depend on these resources for their livelihood.

1.10 Management responses

In Melanesia, different strategies have been used by NGOs, government and researchers to find the most appropriate solution to help communities meet their livelihood needs. Most NGOs and researchers have identified marine protected areas as one of the tools to address the problem of reef resource degradation and scarcity (Weiant & Aswani, 2006; McClanahan *et al.,* 2006; Bartlett *et al.,* 2009; Aswani *et al.,* 2012; Jupiter & Egli, 2011;). Marine protected areas are generally built upon existing local management practices and on a good understanding of the socioeconomic context, including community governance and the level of dependency of communities on reef resources (Cinner, 2007; Ferse *et al.,* 2010; Aswani, 2011). One of the methods that has been adopted in the region is the establishment of Locally Managed Marine Areas (LMMAs).

LMMAs are widely used in the Pacific, and especially in Melanesian countries, as a tool for managing reef resources (Govan *et al.,* 2009). Over the past decades, hundreds of communities within the Pacific have established LMMAs to control decline in marine resources (Govan, *et al.,* 2009). The main management tool employed in LMMAs are no-take areas (NTAs) or '*tabu'* areas, though across Melanesia, these *tabu* areas are typically periodically harvested to supply a pulse of food and/or income (Cohen & Foale, 2013). The ecological benefits of well-enforced and well-managed *tabu* areas are well-documented around the world and include: increases in abundance and biomass of targeted species (McClanahan *et al.,* 2006; Lester *et al.,* 2009;); increased recruitment of fish stocks (Russ and Alcala, 1996); and the spill-over of adults and larvae into neighbouring areas (McClanahan & Mangi, 2000). Other suggested benefits include improved food security, improved governance, access to information and services, health benefits, improved security of tenure, cultural recovery, and community organization (Govan, 2009). However, these benefits are generally only realized where local communities can control access, market access is limited, and strong institutions foster compliance with management rules (Cinner *et al.,* 2012). This concept is not new to the region as it has been one of the management strategies that were employed by local resource owners in the past as part of the CMT system (Johannes, 1978).

In Ahus Island, PNG, periodically closed areas (*tabu* areas) and areas where certain gear was restricted were found to have higher biomass and size compared to fished areas (Cinner *et al.,* 2005). These *tabu* areas are opened one to three times per year. Surveys conducted following the opening suggested that the biomass of fish in the *tabu* areas was not significantly affected by the harvest. Further studies conducted in PNG and Indonesia confirmed that periodic closures were successful in increasing the biomass and the average size of fish inside the *tabu* compared to the

biomass of fish in areas open to fishing (Cinner *et al.,* 2005). Cinner and colleagues stated that *tabu* areas are more effective than other management approaches when they meet the livelihood needs, goals and the cultural context of the community, because this is the only way people will comply and enforce management.

A study done in the Solomon Islands to determine the effectiveness of periodically-harvested closures PHCs revealed that even though the biomass of fish increased in the closed area when fishing effort was reduced, the intensity of fishing when the area was opened outweighed the benefits of closure (Cohen *et al.,* 2013). Communities whose livelihoods depend on these reef resources would employ all the available gear to harvest these resources, which sometimes involves the use of destructive gear such as explosives, to meet social and economic needs (Cohen *et al.,* 2013). This was also observed in Fiji, where a single intensive harvest depleted the biomass and fish populations inside a customary marine closure and harvesting was intensified where a market was available within the community (Jupiter *et al.,* 2012). This area was closed after the harvest and after one year, underwater visual census (UVC) results showed that the biomass of fish inside the *tabu* still had not recovered. The effectiveness of a customary marine closure is determined by the period of closure, harvesting intensity, harvesting frequency, target species and gear used when opened. These factors change with space and time (Cohen & Foale, 2013). Cohen & Foale (2013) argued that community-based and co-management policy must be in place for these PHCs to be effective.

Many communities in Melanesia have been empowered to work with government and non-government organizations to make decisions about fisheries management, a process referred to as co-management (Pomeroy *et al.,* 2001; Cinner *et al.,* 2012). This move towards co-management recognizes that local resource users are in a better position to develop and implement some rules than policy-makers (MacNeil & Cinner, 2013). Effective co-management has increased compliance and achieved better management of community-based marine protected areas in Philippines and Indonesia (Campbell *et al.,* 2013; Pollnac *et al.,* 2001). Co-management can be a solution to establishing rules and regulations for the use of inshore reef resources (Aswani, 1998). Most LMMAs in the Indo-Pacific region are governed by local institutions with the assistance and support from government, NGOs and communities (Cohen & Foale, 2013). There should be a better understanding between the different stakeholders on the goals they wish to achieve from these closed areas, and incorporating existing local practices into management strategies will be crucial for sustainability. Any management plan that weakens the traditional fisheries rights and does not include the interest of the local communities will likely lead to non-compliance and enforcement difficulties (Johannes, 1981). It is more likely that communities will comply voluntarily if their livelihoods and wellbeing benefit from it (Clarke & Jupiter, 2010).

Livelihood diversification has been advocated as a key strategy to decrease the vulnerability of resource users that depend on resources that are decreasing or changing (Ellis, 2000a). Fishing is often associated with poor households in coastal communities (Béné *et al.,* 2000; Cinner &

Bodin, 2010). It can also contribute to their cultural and personal identity (Pollnac & Poggie, 2008; Cinner, 2014). Motivating coastal households that rely on fishing for their livelihoods and cultural purposes to engage in an alternative occupation can be challenging (Pollnac, 1982). Households that have i) multiple occupations and ii) participate in the discussion of community-based management where benefits will be shared equally, can exit fisheries thus reducing the exploitation of reef resources (Pollnac, *et al.,* 2001; Cinner *et al.,* 2009; Cinner & Bodin, 2010; Cinner, 2014). Studies from coastal communities in the Pacific have suggested that diversification of livelihoods into non-fishing activities can have tremendous benefits (Cinner *et al.,* 2005; Turner *et al.,* 2007). A study in Indonesia demonstrated that lack of livelihood diversification can be attributed to lack of education, lack of opportunities and a lack of resources (Ferse *et al.,* 2012).

The introduction and implementation of FADs, small pond aquaculture and mari-culture, deep reef slope fishing and other alternatives outside the fisheries sector have been used by fisheries agencies in the Pacific to reduce the pressure imposed on inshore fisheries (Bell *et al.,* 2009; Gillett *et al.,* 2008). These are applicable only in certain communities in Melanesia. The use of FADs in PNG and Solomon Islands is effective and efficient because they have canoes with which they can paddle out to FADs. In Fiji this will be a problem because most communities don't have canoes but boats with engines and so they require fuel to access the FADs to fish. A study in some remote islands in Fiji found that even though 80% of the communities fish, they do not depend entirely on it for their livelihood because they have other sources such as carving and copra (Turner *et al.,* 2007).

Reviewing studies that have been conducted in Melanesia shows a projection that most coastal communities' livelihoods will be affected if the exploitation of reef resources continues to increase. Population numbers and the demand for fish in Melanesia will continue to grow and there should be a focus on the different types and availability of livelihood assets to coastal communities and develop livelihood strategies based on these assets. Researchers should investigate the drivers that have changed reef resource use in the region.

1.11 Review of coastal livelihoods in Melanesia

A livelihood comprises the capabilities, assets and activities required for making a living by an individual, household or community (Scoones, 1998). The livelihood concept is discussed thoroughly in Chapter 2. In Melanesia, agriculture, fisheries and tourism are extremely important to human livelihoods and wellbeing; therefore any alteration to these three sectors would affect households and communities that depend on them for ecosystem goods and services (FAO, 2008; Lal *et al.,* 2009; Butler *et al.,* 2014). Their remote location, poor access to markets, poorly developed infrastructure and limited institutional capacity hinder economic development and affect livelihoods (FAO, 2008).

In the Solomon Islands, rural people acquire food and income through various activities such as shell diving, fishing, marketing of local produce, handicrafts, copra production and operating small stores in the villages (Aswani, 2002). The harvesting of marine resources in coastal communities in Solomon still constitutes the most important income-generating activity for most households. Fijian society has traditionally relied heavily on marine resources for their subsistence and livelihood (Teh *et al.,* 2009). Fiji has been highlighted as one of the countries that is highly vulnerable to coral reef degradation (UNEP, 2014). Coastal communities in Melanesia are highly dependent on fishing and related fish processing industries and tourism, and will suffer both in terms of economic and food security as a result of reef degradation. Although some Melanesian fishers may have access to land and thus can move into agricultural production as an alternative to fisheries, most coastal communities prefer fin fishing for income rather than agricultural production (Kronen *et al.,* 2010). With reef resources decreasing in Fiji and Solomon Islands, households within communities that are heavily dependent on fishing for income and livelihood would be most vulnerable.

1.12 Research rationale

A sustainable supply of reef resources is essential to the livelihoods of Melanesian island communities. A decrease in reef resources affects the communities that depend on them. Population increase, market access and demand, human-induced changes such as overfishing as well as climate change are putting strong pressure on the reef resources. There is still a substantial lack of knowledge as to how these threats are impacting and adversely affecting livelihoods at the household level.

Melanesian communities face the challenge of living with these threats. The need to understand how communities cope with and adapt to these changes is important, therefore management strategies need to be put in place to promote the sustainable use of the reef resources and to ensure the well-being of the people that depend on them. Although studies and reports have tried to look at livelihoods and adaptations in Fiji and the Solomon Islands (Govan, *et al*, 2009; Schwarz *et al.,* 2011; Bell *et al., 2011;* SPC., 2014; Bell *et al.,* 2015), there has been little research that has focused on household vulnerability in terms of livelihood assets. This information is important in developing strategies that assist households and communities in their attempts to mitigate, cope with and adapt to the different changes they are experiencing.

This research examines the extent to which livelihood vulnerability exists in coastal communities of Fiji and Solomon Islands by analyzing different socio-economic factors. An understanding of the different livelihood strategies that are employed by households is fundamental to the planning of sustainable livelihood activities and intervention strategies.

1.13 Research objectives and questions

The main aim of this research is to understand how households are vulnerable to different social-ecological changes and to outline their capacity to cope with and adapt to these changes.

The objectives of this research are to:

i) Identify the drivers of marine resource use in Fiji and Solomon Islands.
ii) Examine and understand the conditions that determine household livelihood vulnerability to reef resource availability of coastal communities.
iii) Explore potential adaptive and transformative strengths of households in Melanesia under potential future changes in reef resource availability

The following questions address the objectives of this study:

1. What are the drivers of reef resource use in Fiji and Solomon Islands?

2. What are the different factors that determine the livelihood vulnerability of a household or community?

3. How are the livelihoods of households and communities affected by a decrease in reef resources?

4. What livelihood options do households have in order to respond to different stresses and scenarios of change?

2 Chapter 2 Concepts and Framework

2.1 Vulnerability

2.1.1 Concepts and origin

In recent years the concepts of vulnerability, resilience and adaptive capacity have been widely and increasingly used in the discussion of the human and social dimensions of global environmental change (Cutter, 2003; Walker *et al.,* 2004; Adger, 2006; Folke, 2006; Gallopín, 2006; Smit & Wandel, 2006; Allison *et al.,* 2009). The concept and definition of vulnerability evolved from research on risk and natural hazards (Hewitt, 1983; Burton *et al.,* 1993). The word "vulnerability" is derived from the Latin word *vulnerare* meaning 'to wound' (Rygel *et al.,* 2006). In simple terms vulnerability can be defined as "the capacity to be wounded" (Dow, 1992) or "the potential for loss" (Cutter, 1996).

In 1929 Dewey proposed the idea that humanity lives in a hazardous world full of insecurity. In this, hazards are shaped and defined by human actions (Dewey, 1929 cited in Mileti, 1999). Therefore disaster and hazard research have evolved to incorporate the concept of vulnerability in social, cultural and economic terms (Greiving, 2006). The concept has also been widely used in the study of climate impacts and resilience and poverty (Sen, 1981; Kasperson *et al.,* 1988; Chambers, 1989; Kelly & Adger, 2000; Berkes & Jolly, 2001). The concept of vulnerability has been used as a "tool to evaluate the susceptibility to harm of both physical and social systems and the relevant actions to improve human well-being by reducing risks" (Adger, 2006:268).

Vulnerability and its application depends on the geographical area being studied and the characteristics of the particular social, biophysical and the coupled social-ecological systems (SES) (Gallopín, 2006). It is the combinations of the social and biophysical factors and how they react to an event in nature that determine the vulnerability of a social-ecological system (Blaikie *et al.,* 1994). Many natural hazard scholars have focused on the vulnerability of people, communities, and regions to the impacts of environmental change and in particular climate change (Janssen *et al.,* 2006). Many studies on natural hazards and natural disturbances have investigated hurricanes, storms, famine, flooding etc. (Hewitt, 1995) and how people have coped with and adapted to them (Blaikie *et al.,* 1994). Stress has been defined in the social context as any disruption to an individual or group's livelihood and forced adaptation to the changing environment (Adger, 2000). **The term *stress or stressor* is used in this study to refer to human and natural disturbances (such as cyclones, tsunami) that affect the availability of reef resources in coastal communities of Solomon Islands and Fiji. The term stress will be used instead of hazard throughout this thesis.**

2.1.2 Definitions of vulnerability

A number of authors have defined vulnerability in past decades in way that attempt to capture variations in the types of stressors that systems or communities go through (see Cutter, 1996). All these concepts of vulnerability still firmly relate to the different definitions that Cutter discussed in 1996 (see Cutter, 1996). However the general definition does not stipulate the type of loss the individuals, groups or societies experience but rather provides an in-depth knowledge of the development of the concept of vulnerability over the last decades (Dow, 1992; Cutter, 1996). Table 2.1 lists the definitions of vulnerability that have been used in recent studies.

Table 2.1: Definitions of vulnerability

Authors	**Vulnerability Definition**
Clark *et al.,* 2000: page 2	'the risk of adverse outcomes to receptors or exposure units (human groups, ecosystems and communities) in the face of relevant changes in climate, other environmental changes and social conditions'
Turner *et al.* 2003: page 8704	'the degree to which a system, subsystem or system component is likely to experience harm due to exposure to a hazard which may be either a perturbation or a stressor'
Gallopin 2006: page 294	'the susceptibility to harm, a potential for a change or transformation of the system when confronted with a perturbation rather than as the outcome of this confrontation
Adger 2006: page 268	'the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt'
International Panel for Climate Change (IPCC) 2007: page 883	'the degree to which a system is susceptible to and unable to, and unable to cope with, adverse effects of climate change and is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system'
Cutter *et al.,* 2009: page 2	'the susceptibility of a given system or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to and respond to and recover from hazards and disasters'

All definitions of vulnerability above include the susceptibility of different systems in general to harm by stresses and indicate how these systems can respond and adapt to these stresses. Cutter (1996) states that exposure to biophysical and technological risks can have adverse consequences on social systems. Social vulnerability has also been defined by different researchers (Table 2.2).

Table 2.2: Definitions of social vulnerability

Authors	Social Vulnerability
Adger, 2000: page 348	'the exposure of groups of people or individual to stress as a result of the impacts of environmental change'
Cutter, *et al.,* 2003: page 243	'the product of inequalities – the social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond'
Cutter and Finch, 2008: page 2301	'is a measure of both sensitivity of a population to a natural hazard and its ability to respond to and recover from the impacts of hazards'

Social vulnerability, according to the definitions in Table 2, refers to how people, populations, communities and social groups are affected by different stresses. Social vulnerability is not only caused by environmental changes (Adger, 2000) but also by anthropogenic and social factors which include: lack of access to resources (knowledge, technology, marine and land based resources), limited access to political power and representations, social capital, social networks, beliefs and customs, human capital and physical capital (Cutter *et al.,* 2003).

Cutter & Finch (2008) argue that social vulnerability is complex and dynamic and that it changes with space and time. This is evident from studies in the US where it was found that components of social vulnerability which were initially concentrated in certain geographic regions have become more dispersed over time (Cutter and Finch, 2008; Cutter *et al.,* 2003). Vulnerability to environmental change varies among different people within a society, where marginalized groups such as the poor or migrants are often found to be more vulnerable (Béné, 2009). Natural disturbances, hazards and different levels of stress have shaped and transformed the structure of most communities (Turner II *et al.,* 2003b). A good understanding of how vulnerable a system is and what specific conditions make it vulnerable is necessary to help develop actions that will minimize the impacts of environmental change on people (Cinner *et al.,* 2013).

For the purposes of studying livelihood vulnerability of coastal communities in Melanesia, vulnerability is here understood as the susceptibility of coastal households and communities to reef resource degradation and their ability to cope with its effects. The terms fisheries and reef resources which are used interchageably in this study refer to reef fishes only. Applying approaches following Cinner *et al.* (2012), this research focuses on the

livelihood vulnerability of coastal communities in Fiji and Solomon Islands to changes in reef resource availability. A decrease in reef resources poses a serious threat to the livelihoods of communities that are highly dependent on these resources for their survival (Allison & Ellis, 2001).

There are several studies that have looked at social vulnerability to disasters, climate change, famine, and poverty (Watts & Bohle, 1993; Cutter, 1996; Adger, 1999; Kelly & Adger, 2000; McClanahan *et al.,* 2008; Ribot, 2011), but few studies have specifically assessed dependence on marine resources as one of the causes of livelihood vulnerability of coastal communities (Allison & Ellis, 2001; Schwarz *et al.,* 2011 Cinner *et al.,* 2012). Rygel *et al.* (2006) propose that practitioners in a vulnerability assessment must determine which conceptual framework and analytical definitions of vulnerability are to be applied in their study. Alwang *et al.* (2001) state that practitioners from different disciplines (and even from different perspectives within the same disciplines) use different meanings and concepts of vulnerability, which in turn have led to diverse methods of measuring vulnerability. This study adopts the vulnerability framework developed by Marshall & Marshall (2007) which is discussed in detail later in this chapter.

In this thesis, the term vulnerability is used as defined by the IPCC (2007), where vulnerability is understood as a function of a system's exposure, sensitivity and adaptive capacity. Studies have tried to implicitly integrate ecological and social vulnerability by using sensitivity to represent response of the ecological components to changes in climate and adaptive capacity and to represent the response of the social system to changes in the biophysical system (Allison *et al.,* 2009; Marshall *et al.,* 2013). In trying to build resilience in a community, it is important to characterize and understand the properties that determine sensitivity and adaptive capacity of the ecological and social systems (Dolan & Walker, 2004; Cinner *et al.,* 2011; Cinner *et al.,* 2012; Amos *et al.,* 2015).

2.1.3 Components of vulnerability: Exposure, Sensitivity and Adaptive Capacity

Most frameworks and studies have looked at vulnerability in three dimensions; exposure, sensitivity and adaptive capacity (Adger, 2000; Kelly & Adger, 2000; Adger & Vincent, 2005; Adger, 2006; Smit & Wandel, 2006; Gallopín, 2006;Allison *et al.,* 2009; Cinner *et al.,* 2012).

Exposure in this study is defined as the degree to which a system is stressed by different environmental conditions or by socio-political stress in terms of magnitude, frequency and duration (Cutter, 1996; Adger, 2006). As discussed in the 2007 IPCC report, exposure is the extent to which a region, resource or community is exposed to climate-related events. In the context of a fishing community, exposure could be taken as the level to which the marine resources it depends on are affected by environmental change (Cinner *et al.,* 2013). It is critically important to understand that marine resources are not only affected by climate-related events but also human-related activities. Studies have shown that social exposure to resource degradation

can be determined by factors such as overfishing, habitat degradation, market processes (Brewer *et al.,* 2012; Cinner *et al.,* 2012), population growth, urban development, international financial pressures, increase in socioeconomic inequalities and failures in governance (Cannon 2006; Cardona *et al.,* 2012). To address this, communities have implemented no-take marine protected areas, periodically harvested areas and gear restrictions (Halpern & Warner, 2002; Cinner *et al.,* 2005; McClanahan & Cinner, 2008; Cohen & Foale, 2013) but this can aggravate social exposure by reducing the size of fishing grounds available to fishers (Agardy *et al*., 2003; Sanchirico *et al.,* 2002).

Sensitivity in the context of environmental change is the degree to which a defined component of a system is prone to being affected by exposure to stresses (Adger, 2006). Cinner *et al.* (2012) argue that social system sensitivity depends on economic, cultural, political and institutional factors that allow for buffering of change. If communities depend on reef resources as their only source of livelihood or income, they will be very sensitive to any change in reef resources (Béné *et al.,* 2000). Therefore social systems are more likely to be sensitive to a stress if they highly depend on the natural resource affected by this stress (Marshall *et al.*, 2013). In this study sensitivity will be indicated by the degree of dependency of coastal communities on reef resources as their main source of livelihood.

Resource dependency has been used to characterize the strength of linkages between social and ecological systems (Tidball & Stedman, 2012). The term 'resource dependency' has its origin in rural sociology (Freudenburg & Gramling, 1994) and is strongly tied to the extraction of raw materials such as forest products, oil and gas, hard rock mining and fishery resources (Tidball & Stedman, 2012). An extensive literature exists on resource-dependent communities with regards to the extraction and processing of raw natural resources, underlining that social systems that depend on a single resource tend to be more impoverished (Machlis *et al.*, 1990; Nord & Luloff, 1993; Freudenburg & Gramling, 1994; Stedman *et al.*, 2011) and lack the capacity to adapt to sudden changes (Adger, 2000; Adger *et al.,* 2012).

Resource dependency is described as a unique relationship between the users of environmental attributes and the environmental attributes themselves. These are mainly farming, mining, fishing and logging communities (Bailey & Pomeroy, 1996). Therefore a change in the nature of the relationship between users and a resource has the potential to change societal prosperity and affect the resilience of social and ecological systems (Tidball & Stedman, 2012). Tidball and Stedman further argue that the relationship between users and natural resources can have both negative and positive outcomes, but this will depend on to what degree communities are dependent on natural resources.

In tropical marine ecosystems, communities often depend on coral reefs for coastal protection, income, subsistence and recreation as well as social and cultural benefits (Cinner, 2009; Cinner *et al.,* 2009; Pollnac *et al.,* 2010). Exposure and sensitivity are dependent on the interactions and characteristics of the components of the coastal and marine social-ecological system (CM-SES),

and on the attributes of the stimulus or stress (Glaser *et al.*, 2012). The exposure and sensitivity of a community to any stress will depend on the livelihood assets they have or have access to, which in turn will influence their sensitivity to the different exposures. Sensitivity of reef resource-dependent households to declining reef resource availability will be determined by the social, economic, cultural, political and environmental conditions of a community (Brooks, 2003; Smit & Wandel, 2006). Different communities have different sensitivities to stressors, and the scale or duration of the exposure to a stressor affects its impacts on households and communities (Turner, *et al.,* 2003a). Vulnerability is not entirely a product of exposure and sensitivity to certain stressors; it is further determined by the adaptive capacity and the enabling environment of the community (Kelly & Adger, 2000).

Adaptive capacity is the ability of a system to anticipate, respond to, minimize, recover from and cope with different social and environmental changes (Adger & Vincent, 2005; Adger, 2006). A comprehensive definition was given by Gallopín (2006) who defines adaptive capacity in two dimensions; (1) the capacity of the social-ecological system (SES) to cope with environmental conditions and (2) the capacity to improve its condition in relation to its broader environment. Social adaptive capacity is the potential of a coastal community to respond, recover, cope and adjust their behavior and characteristics in the face of existing or anticipated stressors. Nelson (2007) specifically states that adaptive capacity refers to the preconditions that enable adaptations to change.

In the context of climate change, adaptive capacity is defined by the Intergovernmental Panel on Climate Change (IPCC, 2001:3) as "the ability of a system to adapt to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences". The relationship between adaptive capacity and vulnerability has been described differently by various schools of thought, stemming from diverse uses in the fields of development, disaster risk management and climate change adaptation (Cardona *et al.*, 2012). Most studies have described the relationship between vulnerability and adaptive capacity in two ways (Bohle, 2001; IPCC, 2001; Brooks *et al.,* 2005; Smit & Wandel, 2006; Gaillard, 2010):

1) Vulnerability is, among other things, the lack of adaptive capacity
2) Vulnerability is the opposite of adaptive capacity, by which increasing adaptive capacity means a decrease in vulnerability and high vulnerability means low adaptive capacity

There are also links between adaptive capacity and coping capacity, where coping capacity is referred to as the boundaries of systems' ability to survive (Yohe & Tol, 2002). A much clearer definition was given by UNISDR (2009:8), where coping capacity refers to the "ability of people, organizations and systems, using available skills and resources to face and manage adverse conditions, emergencies and disasters". This implies that communities and people go through some stresses but how they cope will depend on the entitlements that they have (Eriksen *et al.*, 2004). While coping aims to maintain the system and its functions in the face of

disturbances, adaptation involves changes that reorganize processes (Cardona *et al*., 2012). Communities and people are more likely to cope with any adverse condition, but the scope for adaptation will depend on the magnitude, frequency and duration of this adverse condition.

Resilience often refers to the ability of a system to absorb shocks and disturbance without undergoing a major structural or functional change (Gunderson, 2000). Scholars using an SES approach have tried to define resilience as a separate component of vulnerability (Berkes & Jolly, 2001; Walker *et al.,* 2002, 2004; Folke, 2006; Brand & Jax, 2007; Maru, *et al*., 2014) but some have concluded that resilience is a component of adaptation and adaptive capacity (Turner, *et al.,* 2003a; Gallopín, 2006; Smit & Wandel, 2006; Young, 2010). I follow the latter interpretation and use resilience as a component of adaptive capacity for this study, since the adaptive measures that communities and household use will not necessarily be ones that were used before. It is important to note that even though some of the adaptive measures taken could be novel, some of the core structures and functions of the community could remain the same. In Melanesia *tabu* areas have been regarded as one of the best tools for the conservation of reef resources, but this is not novel to the region, being a long-standing part of the Melanesian culture. Closures have only been modified by the different NGOs, researchers, government and other institutions that have worked with local coastal communities. Existing adaptive measures and structural functions can be modified to include changes that are introduced by these institutions so that households and communities can get the maximum benefit from their resources.

The capability of a community to adapt is not necessarily apparent instantly after a stress or disturbance, but it is dependent on the strength of the stress and the timescale at which it is occurring (Brooks *et al.,* 2005). The people within the community must reflect on the nature of the disturbance and mobilize their potential and capacity to adjust and adapt. The aim of adaptation is to reduce vulnerability (Brooks, 2003), on the other hand, adaptation measures taken could also increase vulnerability. It is important to understand that some adaptation measures can increase the vulnerability of the other parts of the system. Communities that are more exposed and sensitive to a certain stress or condition will be more vulnerable but this vulnerability can be reduced if they have the ability to cope and adapt to these changing conditions (Smit & Wandel, 2006). Most individuals, households or communities who are closely linked to their entitlements and endowments, i.e. well-endowed with the legal and customary rights to exercise command over resources and food, would be expected to have more capacity to adapt (Sen, 1981; Aswani, 2002;). Cinner *et al.* (2013) mention that communities or people with low adaptive capacity may have difficulty in taking advantage of the opportunities created by changes in the availability of ecosystem goods and services.

2.1.4 Models and frameworks on vulnerability

There are several models and conceptual frameworks of vulnerability that have been developed and widely used (Cutter, 1996; Turner II, *et al.,* 2003b; Brooks, 2003; Adger & Vincent, 2005; Brooks *et al.,* 2005; Blaikie *et al.*, 2005; Marshall *et al.,* 2013). These frameworks have been adopted and adapted by researchers to further develop the concept of vulnerability (Turner II *et al.,* 2003b; Smit & Wandel, 2006; Cinner *et al.,* 2012; Metcalf *et al.,* 2015; Hobday *et al.,* 2016).

There were two early conceptual frameworks that assessed vulnerability: (i) the risk-hazard model (RH), which focuses on the impact of a hazard as a function of exposure to the hazard event and the response (sensitivity) of the exposed entity (Burton *et al.,* 1978); (ii) the pressure and release (PAR) model (Blaikie *et al.,* 1994), where risk is clearly defined as a function of the stressor and is making the exposed unit vulnerable. These two models have limitations which Turner II *et al.* (2003a: 8074) identified. The RH model does not outline "the ways in which the systems in question amplify or attenuate the impacts of the hazard" or make a "distinction among exposed systems and components that leads to significant variations in the consequences of the hazard". Neither does it address "the role of political structures, especially social structures and institutions, in shaping differential exposures and consequences". On the other hand, the PAR model does not address the vulnerability of the biophysical system and it provides little detail on the structure of the hazards' causal sequence including the nested scale of interactions.

The development of the coupled human-environment vulnerability framework by Turner II *et al*. (2003a) conceptually shows the integration between the global environment and human influence and how multiple factors affect vulnerability at different scales (Fig. 2.1). This framework reveals the broad classes of components that comprise a social-ecological or human-nature system's vulnerability to stressors. These are: (i) the broader human and environmental conditions; (ii) stressors that emerge from these conditions; and (iii) the coupled human-environment system of concern in which vulnerability resides, which includes exposure, sensitivity and resilience (here resilience takes the place of adaptive capacity). This framework takes a contextual approach to understanding vulnerability within social-ecological systems. The term social-ecological is used to highlight that the two components are equally important, that they function as a coupled, interdependent and interactive system, and to stress that the delineation between subsystems is artificial (Berkes *et al.,* 2003)

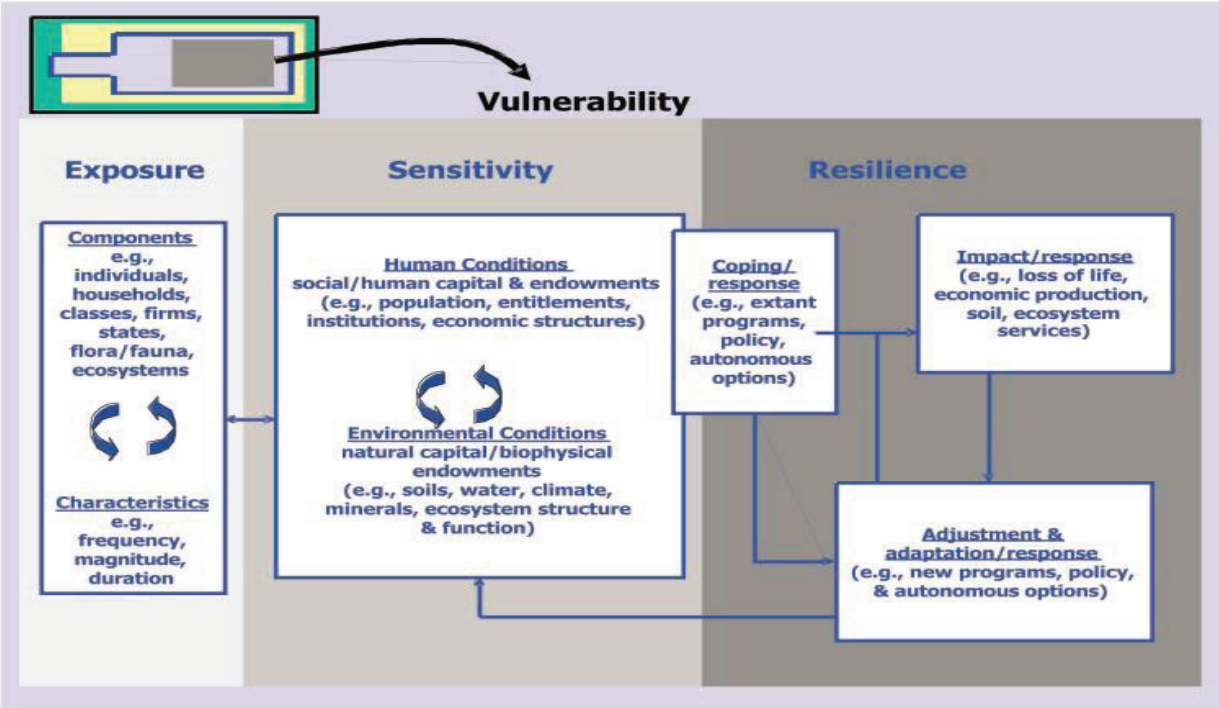

Figure 2.1: The vulnerability framework by Turner II *et al.* (2003a:8076) which explicitly defines vulnerability in terms of exposure, sensitivity and resilience.

The framework (Fig. 2.1) describes the interdependence of the different components (exposure, sensitivity and resilience or adaptive capacity) and the pre-conditions that can determine the vulnerability of a system. In this framework the vulnerability of the people or community in question will be determined by the interaction and state of the human-environment condition and how humans respond when exposed to a certain stress (e.g. decrease in reef resources). Turner II *et al*. (2003a) state that the condition of the human-environment system will determine its sensitivity to any exposure, which will define the different adaptation measures and coping responses that can be used by households and communities. Studies have shown that the vulnerability of human settlements and ecosystems is intrinsically tied to different socio-cultural and environment processes (Kasperson *et al.,* 1988; Adger, 2006; Cutter & Finch, 2008; Williams *et al.,* 2008).

Schroter *et al.* (2004) developed a vulnerability framework to assess European human-environment systems. This framework by Schroter has been used in the assessment of vulnerability to climate change (IPCC, 2007). Further analysis into the framework of vulnerability by Marshall *et al.* (2009) led to the development of another vulnerability framework for assessing vulnerability to climate change in climate sensitive social-ecological systems (Fig. 2.2). There are two vulnerability models integrated in this framework: one represents the components of ecological vulnerability to exposure to climate change, whereas the

other represents social vulnerability to changes in the ecological system. The co-dependency of ecological and social systems means that the vulnerability of one system cannot be reliably evaluated without reference to the other (Eriksen & Brien, 2011). The framework by Marshall used the concept of resource dependency to operationally represent the sensitivity of individual actors to changes in the condition of Great Barrier Reef resources on which their business depends. The framework was used in the vulnerability study of coastal communities in East Africa (Cinner *et al.,* 2012).

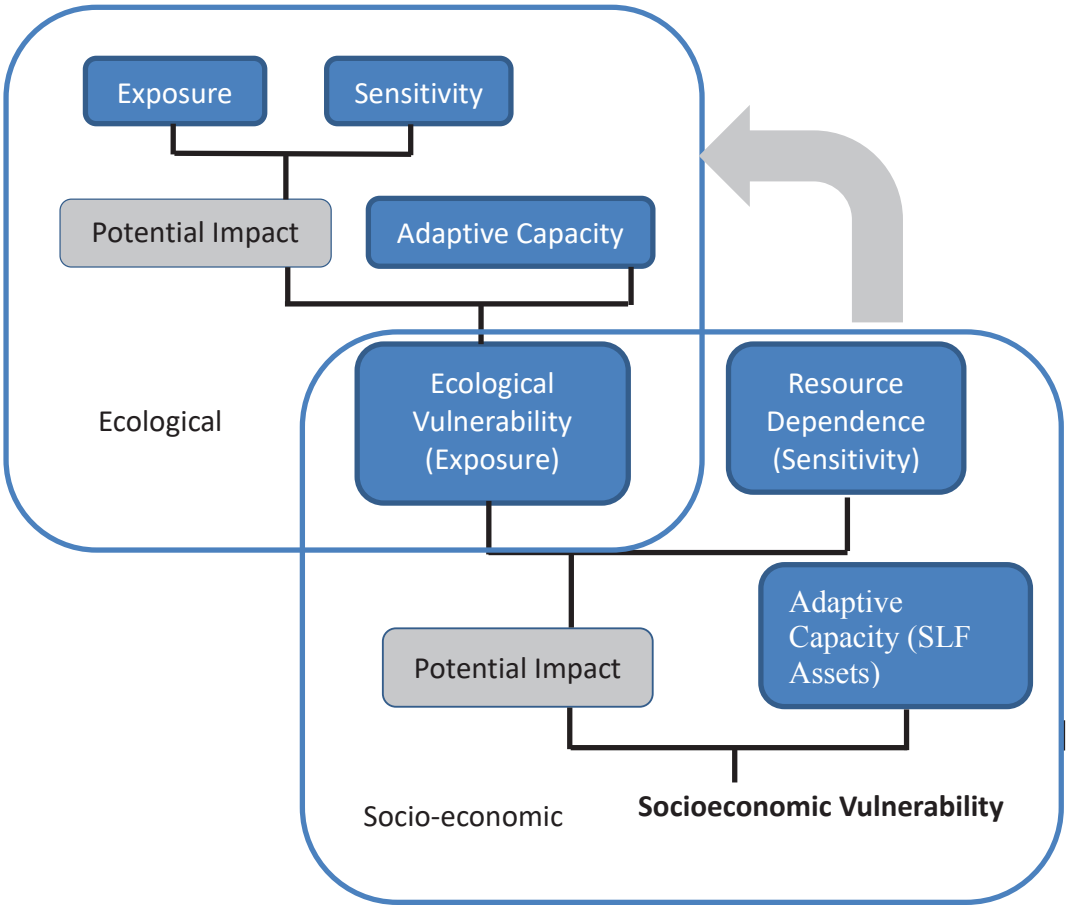

Figure 2.2: Vulnerability framework (adapted from Marshall *et al*., 2009).

Using the framework by Marshall and colleagues, the vulnerability of coastal households and communities (social vulnerability) in Melanesia will be assumed to depend on: 1) the potential impact of degrading reef ecosystems on human communities who depend on them for livelihood; 2) the dependence of communities on these reef resources; 3) the adaptive capacity of households and communities. The framework by Marshall *et al.* (2009) illustrates that the potential impact of ecological exposure on communities depends on the nature of dependence

(sensitivity) of communities on natural resources. Subsequently, their vulnerability will be influenced by the coping and adaptive measures communities have access to.

2.2 Sustainable Livelihoods Framework (SLF)

2.2.1 Defining sustainable livelihoods

Initial discussions on sustainable livelihoods focused mainly on rural areas and agricultural communities, where people make a living from some form of primary self-managed production (Krantz, 2001). With changed definitions and concepts, the SLF can be applied to different social units but the framework has been used mostly at the household level (Chambers and Conway 1991). Livelihood in simple terms can be defined as a means of living. Most researchers have commonly used the definition by Chambers and Conway (1991), which defined sustainable livelihoods as:

"A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provide sustainable livelihood opportunities for the next generation; and contributes net benefits to other livelihoods at the local and global levels and in the short and long term" (Chambers & Conway, 1991:6).

A simpler definition was used by Ellis (2000):

"A livelihood comprises the assets (natural, physical, human, financial and social capital), the activities and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household" (Ellis, 2000: 10)

From the definitions above, 'livelihood' in fishing communities can be termed as activities which would either bring in food or money to an individual or household. These activities depend on the different capitals households can access. **In this study, livelihoods of coastal households in Melanesia will be understood as a function of livelihood assets that households have access to and the households' ability to use these assets.** Most coastal communities in Melanesia depend on marine resources for their livelihood. A decline in these marine resources will threaten the livelihood of households that have limited or no access to other livelihood assets, making them vulnerable.

2.2.2 The origin and concepts of SLF

The concept of livelihoods thinking did not suddenly emerge in 1991 with the working paper by Chambers and Conway (Scoones, 2009). Previous research by economists and Marxist scholars in the fields of agricultural economics and geography, and village studies assessing rural

situations with a focus on micro-economics of farm production and patterns of household accumulation were all early forms of livelihood studies (see Scoones, 2009)). The Sustainable Livelihoods Framework (SLF) entered the development discourse in the 1990s. The perceived inadequacies of the top-down, bureaucratic, market-oriented approaches that dominated the development discourse in the 1950s to 1970s have influenced the growth of SLF (Ellis & Biggs, 2002).

The emergence of the SLF was described by Solesbury (2003:14) as "a paradigm shift from the ideas which are based on top-down and economic growth to a more people or community focus recognizing the importance of assets and communities and the institutional structures that govern them". The expansion of the SLF evolved due to the increased attention on poverty reduction, people-centered approaches, and sustainability in the political arena and development theory and practice (Scoones, 2009).

The idea of sustainable livelihoods was first introduced in the Brundtland report in 1987 under the Commission on Environment and Development of the United Nations (WCED, 1987). It described sustainable livelihoods as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. In 1992, United Nations Conference on Environment and Development (UNCED) expanded this concept and advocated for the sustainable livelihoods approach to be incorporated as an integrated factor that allows policies to address development, sustainable resource management and poverty eradication simultaneously (UNCED Agenda 21, 1992).

The SLF has been developed in order to understand and analyze the livelihoods of poor communities and households and to devise strategies that can meet their livelihood objectives (Chambers and Conway, 1991; Scoones, 1998; DFID, 1999a). The development of the SLF by Chambers & Conway (1991) diverged from the conventional analysis of poverty in terms of production, employment and poverty-line thinking to address the fundamentals of capability, equity and sustainability. The concept of sustainable livelihoods is an attempt to go beyond the conventional approach to poverty reduction, recognizing various other factors and processes which either constrain or enhance people's ability to make a living in an economically, ecologically and socially sustainable manner (Krantz, 2001).

As defined by Sen (1984), capability refers to being able to perform certain basic functions. The capability of actors to use the assets that are available to them is dependent on whether these actors have access or are entitled to these assets (Table 2.3). In most cases, households that depend on reef resources for their livelihood do not have access to central services such as education, health, insurance and economic opportunities (Béné, 2006).

Table 2.3: Definitions of capability, equity and sustainability according to Chambers and Conway 1991

Capability	'livelihood capabilities that include being able to cope with stress and shocks and being able to find and make use of livelihood opportunities'
Equity	'imply a less unequal distribution of assets, capabilities and opportunities and especially enhancement of those of the most deprived'
Sustainability	'the ability to maintain and improve livelihoods while maintaining or enhancing the local and global assets and capabilities on which the livelihood depends'

2.2.3 The sustainable livelihoods framework

The sustainable livelihoods framework (SLF) combines the main factors that affect people's livelihoods and overarching relationships between these factors (DFID, 1999a). The SLF has been used globally to help communities engage in different strategies to achieve their livelihood objectives (Allison & Ellis, 2001; Pomeroy *et al.,* 2006; Ahmed *et al.,* 2010; Forster *et al.,* 2013). The sustainable livelihoods framework, which has been described by Scoones (1998) and DFID (1999), has been developed to specifically help vulnerable communities become more resilient to economic and environmental stressors/shocks and to capitalize on their existing capacities. The SLF arose from a combination of farming systems analysis, micro-economic and institutional analysis, which have been widely adopted for the development of policies and for understanding management of natural resources (Carney, 1998).

Cahn (2006) stated that the SLF may be a more organizing framework and a useful tool in working with impoverished or marginalized communities. It is evident from studies where the SLA framework has been adopted that the framework is most effective in assessing household livelihoods assets where communities tend to draw on a wide range of livelihoods in pursuit of better living standards (Ashley & Hussein, 2000). The framework provides integration between household and community data and analysis of cultural, economic and natural assets (Scoones, 2009).

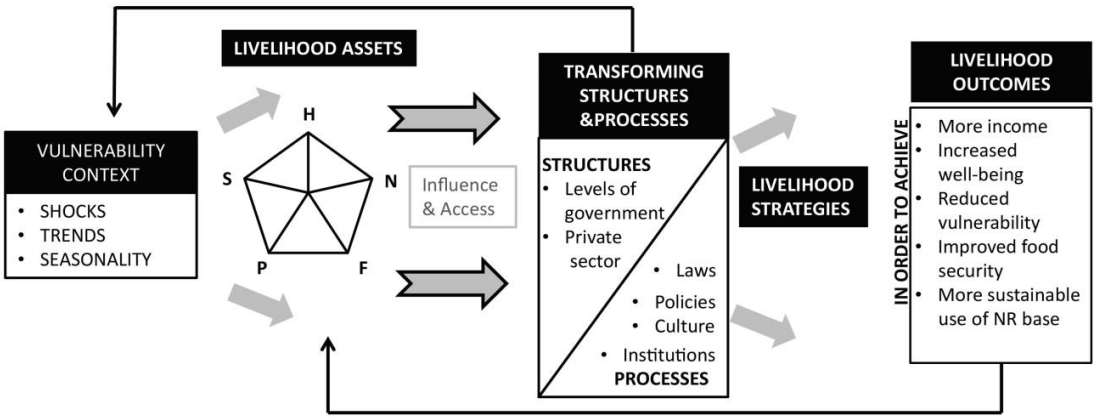

Figure 2.3: The sustainable livelihood framework (DFID, 1999; Scoones, 1998)

Keys: H – Human Capital
N – Natural Capital
F – Financial Capital
P – Physical Capital
S – Social Capital

The DFID guidance sheets explicitly describe the above SLF as:

> "Firstly the approach is people centered in that the making of policy is based on understanding the realities of struggle of poor people themselves, on the principle of their participation in determining priorities for practical intervention and on their need to influence the institutional structures and processes that govern their lives. Secondly it is 'holistic' in that it is 'non-sectoral' and it recognizes multiple influences, multiple actors, multiple strategies and multiple outcomes. Thirdly it is 'dynamic' in that it attempts to understand change, complex cause and effect relationships and 'iterative chains of events'. Fourthly it starts with analysis of strengths rather than of needs and seeks to build on everyone's inherent potential. Fifthly it attempts to 'bridge the gap' between macro- and micro levels. Sixthly it is committed explicitly to several different dimensions of sustainability: environmental, economic, social and institutional." (DFID, 1999:7)

The livelihoods approach has links to the concept of vulnerability: as seen in the SLF framework, any stress (vulnerability context) will affect the different capital assets, leading to different livelihood outcomes. Allison & Ellis (2001) pointed out that the SLA framework comprises the three dimensions of vulnerability, which are exposure, sensitivity and resilience/adaptive capacity. In their discussion they maintain that robust livelihood systems have high adaptive

capacity and high resilience, and that vulnerable livelihoods show low adaptive capacity and high sensitivity. The present study adopts the DFID Sustainable Livelihoods Framework (Fig. 2.3). This framework was chosen because of its potential for linkage to the vulnerability framework. In relation to the vulnerability framework, the dependency of coastal communities on reef resources can be clearly evaluated using the SLF to show how sensitive coastal communities are when these reef resources decrease. On the other hand, the adaptive capacity in the vulnerability context will be determined by assessing the capital assets households have available to them. The access to these assets, as governed by social and economic structures and processes, will define the different livelihood strategies that households engage in.

2.2.4 Livelihood assets

Scoones (1998) states that people require a range of assets or capitals to achieve positive livelihood outcomes, and there is no single asset or capital that on its own can achieve the sustainable positive livelihood outcomes. Therefore, successful livelihood outcomes are dependent on the relative availability of, access to and implementation of all five assets. Table 2.4 provides the definition of these different assets.

Table 2.4: Definitions of the five livelihood assets (Scoones, 1998; DFID, 1999)

Assets	Definition
Human	The skills, knowledge, ability to labor and good health that enable people to pursue different livelihood strategies and achieve livelihood objectives.
Social	The social resources which people rely on (which include networks and connectedness, members of a more formalized group, associations, social relations, relationship of trust, reciprocity and exchanges) that will help them achieve their livelihood objectives.
Natural	Natural resource stocks from which resource flows and services useful for livelihoods are derived. Farmers and fishermen depend on natural resources for their livelihoods and people in urban centres need these resources to provide them with good health.
Physical	The basic infrastructure and producer goods needed to support the livelihood. These are the tools and equipment that people use to function more productively.
Financial	The availability of monetary and financial resources that enable people to adopt different livelihood strategies to achieve their livelihood objective. This includes bank deposits, savings, access to credit and liquid assets, pensions and remittances and also earned income for work.

The problems of overexploitation and degradation of ecological systems are rarely attributed to a single cause but to various interrelated causes which can originate from activities designed to produce desired livelihood outcomes. The aspiration to achieve desired outcomes could be affected by greed, power differences, technical changes and the quest for survival. The pursuit of different livelihood strategies is dependent on the tangible assets (stores and resources) and intangible assets (claims and accesses) that people or households possess (Scoones, 1998).

2.2.5 Social-economic structures and processes

It is important to understand that access to livelihood assets in most places is controlled by social-economic structures and processes. Ellis (2000) stated that livelihoods are based on a platform of assets, which are modified by access (governed by social relations, institutions, organizations) in a context of stressors and shocks. Access to capital is determined by transforming structures (i.e., levels of government, private sector, civil society) and processes (i.e., laws, policies, culture, institutions, power relations; Bennett, 2010). Murray (2001) suggested that livelihoods research should focus on the household or community level (micro) but not overlooking the role of regional, national and international level (macro) in shaping these livelihoods.

In a community setting, processes such as tradition, norms and values have been transferred orally between generations and can change over time. Livelihoods need to be examined as they are to be found in the present, retrospectively (change overtime from past) and prospectively (for future policy action) (Murray, 2001). Livelihood assets are highly influenced by structures and processes that have significant impact on communities, households and individual (Scoones, 2009).

2.2.6 Livelihood strategies and outcomes

Livelihood strategies are the combinations of activities and assets that people engage in as a means of household survival. These activities can be sustainable or unsustainable (Ellis, 2000a; Martin & Lorenzen, 2016). Strategy is defined as "a plan that is intended to achieve a particular purpose" (Hornby *et al.*, 1974:1284). Livelihood strategies include productive activities, investment strategies and reproductive choices which could be natural resource-based activities and non-natural resource-based activities (including remittances and other transfers) (Ellis, 2000). A major influence on people's choice of livelihood strategies is their access to assets and the policies, institutions and processes that affect their ability to use these assets and achieve positive livelihood outcomes (Carney, 1998; Alinovi *et al.*, 2010; Badjeck *et al.*, 2013; Shameem *et al.,* 2014). As stated by Cahn (2006), livelihood strategies are not static: they change as the external environment, policies, institutions and processes and control over assets change.

Scoones (1998) emphasizes that understanding the dynamic and historical context of how different livelihood resources are sequenced and combined is important in the pursuit of different livelihood strategies, which can be categorised into three: agricultural intensification, livelihood diversification, and migration. Scoones (1998) interpreted livelihood diversification as developing a widely ranging income portfolio (temporary or permanent) either to cope with adverse conditions or for accumulation and reinvestment. Ellis (1999:2) furthermore defined rural livelihood diversification as "the process by which households construct a diverse portfolio of activities and social support capabilities for survival and to improve their living standard". Livelihood diversification decreases pressure on local resources, enhances people's options, builds individual human capital, increases cash flows to and within rural areas and promotes spatially diverse transactions (Ellis & Allison, 2004). Livelihood diversification does not always result in positive outcomes due to social, cultural and economic factors (Stanford *et al*, 2014; Mutabazi *et al.*, 2015; Matera, 2016).

Scoones (1998) reported that rural livelihood strategies are often heavily reliant on the natural resource base. A study in Laos distinguished agricultural and non-agricultural livelihoods, showing that richer households were more involved in non-agricultural activities than poorer households (Bouahom *et al.,* 2004). The different strategies households or communities engage in are driven by the livelihood outcome they desire. The livelihood pathway and portfolio combinations households choose could result in positive livelihood outcomes but this is dependent on context (Scoones, 1998). These desired outcomes would include improved wellbeing, improved food security, increase in income, reduced vulnerability and sustainable use of natural resources, but these are context specific (DFID, 1999).

2.2.7 Uses and critiques of the sustainable livelihoods framework

The sustainable livelihoods approach has been used as an analytical and heuristic tool (Ellis & Allison, 2004; Ferrol-Schulte, *et al.,* 2013; Blythe *et al.,* 2014; Martin & Lorenzen, 2016). It has helped researchers to understand the nature of poverty and presented the links between different aspects of people's livelihoods (Alinovi *et al.,* 2010; Ferrol-Schulte *et al.,* 2014). There are numerous studies that have used the livelihoods approach as a research strategy or as a research tool to address poverty, food security and vulnerability to climate change (Barrat *et al.,* 2001; Ellis & Allison, 2004; Cinner *et al.,* 2012; Shameem *et al.,* 2014; Metcalf *et al.,* 2015). Ashley & Carney (1999:7) suggested that the SLF was useful for: 1) the systematic and holistic analysis of poverty; 2) providing an informed view of development opportunities, challenges and impacts; and 3) placing people at the centre of development work. Carney (2002) and Hussein (2002) add that the approach also: 4) improves the understanding of poor people's lives; the constraints facing them and inter-group differences; 5) increases inter-sectoral, collaborative and interdisciplinary community development research; 6) creates increased links between micro-, meso-, and macro-level considerations in the poverty and development discourse. The SLF is a

useful tool to analyze coastal and marine resource dependent livelihoods in the small scale fisheries context (Allison & Ellis, 2001).

There are a number of critiques of the sustainable livelihood approach. Ashley & Carney (1999) specifies three early critiques of the SLF: 1) the potential costliness of the process; 2) the over-emphasis of the SLF on vocabulary and processes, and 3) the need for additional tools and skills to complement various aspects of the framework and to support changed agendas.

Morse and MacNamara (2013: 43-46) list six critiques of the SLF: 1) despite the people-centred rhetoric of SLF, people are strangely invisible in policies, and absent from the SLF are important values such as culture and leisure; 2) it is unclear how to analyze and measure capitals within the SLF; 3) the importance of trust and openness where questions being asked can be sensitive; 4) the SLF could result in much detailed analysis, but how is this to be translated into effective intervention policy is a major question to be answered; 5) while there is an attempt to assess vulnerability (shocks, trends etc.) there is much unpredictability at the macro-scale. Carney (2002) identified the SLF is limited in addressing gender, power, rights, governance, markets, economics and broader institutional issues. Since the SLF cannot include everything in its analysis, it is critically important that other frameworks are considered (Cahn, 2006). The SLF should not be viewed as a rigid template for rural development but rather as an adaptable and guiding framework for development planning and intervention (Morse & McNamara, 2013).

2.3 Use of the vulnerability and sustainable livelihood framework in this research

The inclusion of the SLF into the vulnerability framework is significant when trying to measure livelihood vulnerability of households and communities. For the purposes of this research, the SLF (DFID, 1999) was incorporated into the vulnerability framework developed by Marshall *et al.,* (2013) to address specific questions raised. According to the SLF, the livelihood assets that people or households depend on are affected by shocks, trends and seasonality. As defined by Scoones (1998), 'stress' or 'trend' is a small, regular, predictable disturbance with a cumulative effect while 'shock' is a large infrequent, unpredictable disturbance with immediate impact. Trends include: population trends, national economic trends and natural resource trends, and shocks include: droughts, floods, hurricanes, fires and epidemics. Seasonality includes changes in prices, employment opportunities and health. Stresses and shocks on ecosystem goods and services could affect households and communities making them vulnerable. People depend on ecosystems for survival and wellbeing (Daw *et al.*, 2011), but actions by human society have been the driving force behind global environmental changes (Zickfeld *et al.*, 2017). Natural and anthropogenic factors (directly or indirectly interacting at multiple, temporal and spatial scales) cause changes in ecosystems, thereby affecting ecosystem services and livelihoods of people that depend on them (Carpenter *et al.*, 2006).

Vulnerability is a characteristic of linked social-ecological systems; one that is shaped by multi-level interactions between social, political, economic and ecological structures and processes (Adger, 2006). Therefore to assess livelihood vulnerability, it is important to understand how components of vulnerability and fishery-based livelihoods interact (Islam *et al,.* 2014). The livelihood vulnerability of most coastal communities around the globe has been a focal point for many researchers. While a number of studies have investigated the impact of climate change on the vulnerability and adaptive capacity of fisheries sectors at the national scale (Allison *et al.*, 2009; Hughes *et al.,* 2012), little research has examined vulnerability of small scale fishers to decreasing reef resources caused by stresses and shocks in developing small island nations such as Fiji and Solomon Islan

3 Chapter 3: Methods

3.1 Study Region

3.1.1 Country selection

The Pacific Islands are a region where societies are closely linked to the coral reef ecosystems surrounding them. At the same time, the region's reefs are strongly affected by global environmental and socio-economic changes such as changes in seawater temperature and level, an increasing integration of local markets with the global economy, natural disasters and human impacts (Bell, *et al.,* 2011; Foale & Manele, 2004) . The social-ecological connectedness in the area potentially reinforces these impacts and means that environmental change can have particularly severe consequences for local societies (Kronen *et al.,* 2012). This study was conducted in coastal villages in Fiji and Solomon Islands. These two countries belong to the Melanesian group of islands in the South Pacific and were chosen for this study for the following reasons:

i) They are the most populated countries in the region apart from Papua New Guinea
ii) They are highly dependent on natural resources for food and livelihoods

All sites chosen for this research were previously studied by researchers and NGOs but there is yet to be research done that specifically looks at the drivers of livelihood vulnerability. Almost all villages involved in this study have previously or currently engaged in marine management (*tabu* areas) but the effectiveness of these management practices is unclear. The only village that was never involved in any marine management is the village of Raromana in the Solomon Islands.

3.1.2 Research site selection criteria

In December 2013, a reconnaissance visit was undertaken in each country to choose study sites. A workshop was held in the last week of February 2014 where communities from each country were chosen based on certain assumptions which are listed below.

i) The households and community's dependence on reef resources. The dependence on reef resources varies from low to high for both countries.
ii) Greater and smaller distances of the communities to markets for reef products.
iii) The size of the communities within the country should be similar.
iv) The villages should have or have had a type of management in place for their marine system. This could be in the form of traditionally closed area (*tabu)*, periodically closed area, species-specific closure, gear restrictions etc.

v) The availability of socio-economic data for at least one site per country from previous projects by project partners e.g. PROCFish[2]

This study uses the term community rather than village. The term community has been defined in numerous studies (Agrawal & Gibson, 1999; du Toit *et al.,* 2004; Govan *et al.,* 1998) and it can be used to describe an area larger than a village and can consist of different actors with different interest and norms (Agrawal & Gibson, 1999; Armitage, 2005; Ferse *et al.,* 2010). The communities in Fiji are homogeneous (fewer migrants) compared to the more heterogeneous communities in Solomon Islands (Aswani *et al.,* 2017). The term 'community' in this study refers to a group of people or households who live or work in the same geographical area and share the same resources, values, morals and culture**.**

3.1.3 Fiji

Fiji is an archipelago of mostly mountainous islands of volcanic origin located between 176° 53′ east and 178° 12′ west. It consists of more than 300 islands of which more than a hundred are inhabited. It has a land area of 18,300 square kilometres (Vuki *et al.,* 2000). Fiji is mainly tropical with only slight seasonal temperature variation with a cooler dry season from May to October and a hot wet season from November to April (http://www.southpacific.org/pacific/weather).

The total water area and Exclusive Economic Zone (EEZ) for Fiji is estimated around 1.29 million km^2 (Ahmed *et al*., 2011). The fisheries sector in Fiji contributed about 1.83% of the annual gross domestic product for 2014 (Gillett, 2016). Approximately 42% of total marine fisheries production in Fiji is from coastal subsistence fishing (Gillett & Cartwright, 2010) and 58% from offshore fishing and coastal commercial fishing. Coastal subsistence fisheries production had an estimated value of $54FJD million (~USD$26 million) in 2014 (Gillett, 2016).

The majority of Fiji's population live on or near the coast on the two big islands of Viti Levu and Vanua Levu. With limited land resources, many indigenous Fijians in coastal villages rely on marine resources from their fishing grounds for food and livelihood. These fishing grounds are under a well-established system of legally recognized customary fishing rights areas called (*iqoliqoli*). There are 410 *iqoliqoli* which have been mapped and demarcated by the Fiji government under the Fiji Native Lands and Fisheries Commission (Mathews *et al.*, 1998). Although clans, tribes and communities own customary fishing rights, the state owns the waters and marine resources between the high water mark and the EEZ.

[2] Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish) was aimed at providing baseline information on the status of reef fisheries and help in the effective management of reef fisheries.

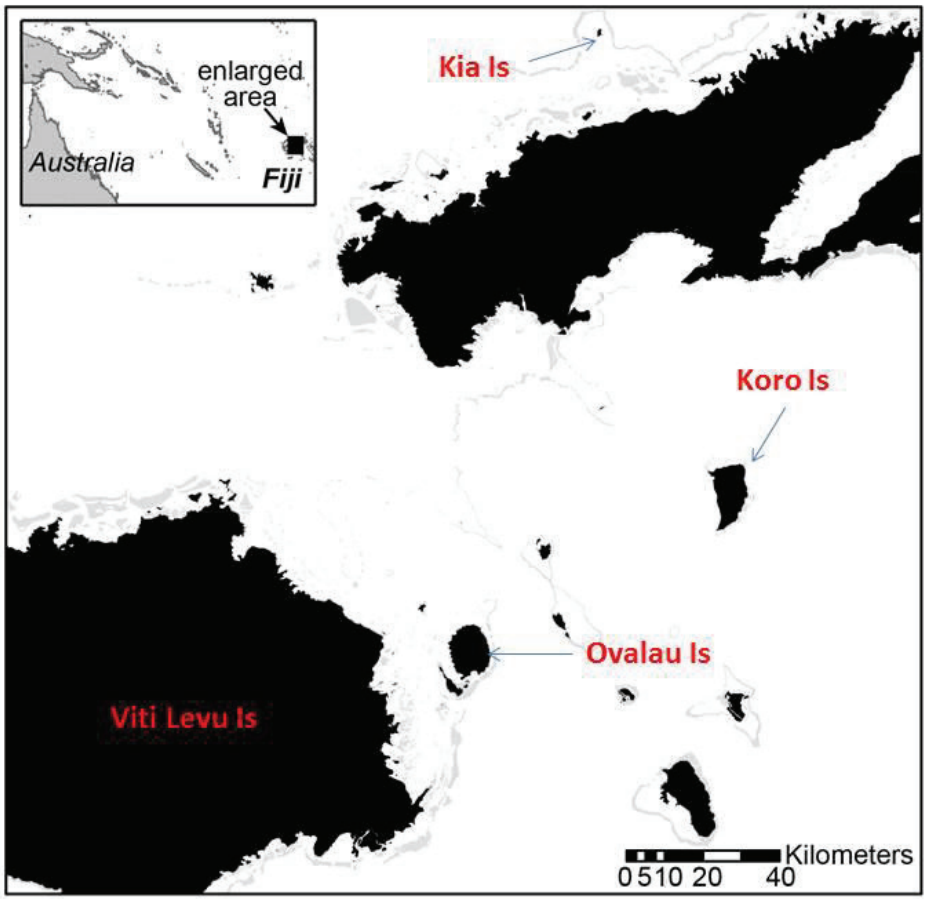

Figure 3.1: Map of Fiji showing research sites

Ten communities from four different islands were used as study sites. The islands were Viti Levu, Koro, Ovalau and Kia (Fig. 3.1).

3.1.3.1 Viti Levu Island

Viti Levu is the largest island in Fiji. The communities of Muaivusu, Nabaka, Namakala and Waiqanake are located approximately 10km west of the capital of Fiji, Suva (Fig. 3.1). They have one chief and a demarcated *iqoliqoli* (fishing ground) for the 4 communities. The four communities collectively have an existing *tabu* area which has been closed since 2003 and opened only once in 2010 for two weeks. Although these communities are close to Suva, most of the households rely on reef resources for their livelihood. The availability of markets within the urban centre in Suva has placed a lot of demand on fishers to fish more resulting in increased harvesting of reef resources. The inshore reefs of their *iqoliqoli* are adjacent to the major urban

and industrial precinct of Suva, hence the reefs are exposed to land based pollution and poaching. Some community members work in Suva, mainly in casual jobs. Access to these villages is through public (bus and taxis) and private transport by road. This was one of the PROCFish sites that were surveyed by SPC in 2009. The total number and percentage of households surveyed in Fiji is shown in Table 3.1.

Table 3.1: Total number of households, number of households surveyed and percentage of households for the 10 study communities in Fiji

Community	**Total number of households**	**Number of household surveyed**	**% of households surveyed**
Muaivusu	33	24	71
Nabaka	25	16	64
Waiqanake	51	30	59
Namakala	35	20	57
Tuatua	66	41	62
Nakodu	53	40	75
Yaro	24	16	67
Ligau	12	8	67
Daku	8	6	75
Natokalau	80	42	53

3.1.3.2 Koro Island

The island of Koro is the sixth largest island in Fiji and it is accessible by plane or ferry from the capital Suva. The two communities surveyed were Tuatua and Nakodu. These two communities have their own *iqoliqoli*, each of which is managed separately. The two communities have existing *tabu* areas which are managed locally. Although residents live close to the sea and have a *tabu* area, people mainly fish for subsistence because they do not have any stable market where their catch could be sold. Households have access to fertile land and markets for their produce. The two major crops are *taro* and *yaqona* (dried root and stem of *Piper methysticum*). *Yaqona* is sold locally while *taro* is exported. The total number and percentage of households surveyed is shown in Table 3.1.

3.1.3.3 Kia Island

The island of Kia is located 30km off the second largest island in Fiji, Vanua Levu. The island consists of three communities, Daku, Ligau and Yaro which all belong to the province of Macuata. These three communities heavily depend on marine resources for their food and livelihood as there is little fertile land on the island. Crops planted are mainly for household consumption but cannot sustain households all year. A *tabu* area was established for the three communities in 2005 and opened in 2010. The *tabu* has remained open since 2010. A proposal

from all three communities has been made to the chief and elders to reinstate the *tabu*. The total number and percentage of households surveyed is shown in Table 3.1.

3.1.3.4 Ovalau Island

The island of Ovalau is located approximately 20km off the east coast of Viti Levu Island. Natokalau was the only community surveyed from Ovalau Island. The community depends on reef resources for food and livelihood, but farming also takes place. The Pacific Fishing Company (PAFCO) which is based in Ovalau provides employment to people of Natokalau. The community have an existing *tabu* which has been permanently closed for 10 years and a part of this *tabu* is periodically harvested for village feasts and funerals. Its *iqoliqoli* is shared with four other villages, providing challenges for management. The total number and percentage of households surveyed is shown in Table 3.1.

3.1.3.5 Socio-demographic characteristics

The socio-demographic characteristics for the communities studied in Fiji are shown in Table 3.2. The total number of households surveyed in Fiji was 246, with 194 fishers and 52 non-fishers. More males than females were interviewed. Most respondents were aged 29-59 and more than 80% were married. The education level in both groups was low with most respondents having left the education system at the completion of either primary or secondary school. Most households owned land while those that did not had access through land owned by clans. Most (87%) of households were Methodists while other religious groups (all Christian) accounted for the remaining households and the communities were all indigenous Fijians.

Table 3.2: Demographic characteristics of household respondents from Fiji

Variable	Fishers (N=194; 79%)		Non-Fishers (N=52; 21%)	
	N	%	N	%
Gender				
Male	127	66	32	62
Female	67	34	20	38
Age				
18-28	17	8.8	3	5.8
29-38	39	25.3	13	25
39-48	49	25.3	9	17.3
49-59	49	25.3	11	21.2
>60	40	20.6	16	30.8
Marital status				
Married	166	85.6	38	73
Single	12	6.2	5	10
Divorced	2	1	1	2
Widow/Widower	14	7.2	8	15
Education				
Primary	87	45	20	39
Secondary	101	52	29	56
Tertiary	6	3	3	5
Own land				
Yes	170	88	47	90
No	24	12	5	10
Religion				
Methodist	170	88	44	85
Others	24	12	8	15

3.1.4 Solomon Islands

Solomon Islands is an archipelagic country mostly with rugged mountains with some low coral atolls located east of Papua New Guinea. It consists of 6 major islands and more than 900 smaller islands with a land area of 28,000 square kilometres, making Solomon Islands approximately 40% larger than Fiji (Hviding & Baines, 1994; SPC-SDD, 2016). Solomon Islands is tropical with weather variations from tropical monsoon to weather extremes (http://www.southpacific.org/pacific/weather).

The EEZ for Solomon Islands is approximately 1.3 million km^2 (Rosegrant *et al*., 2015). Fisheries resources contributed 2.4% of the annual total GDP in 2016 (Gillett, 2016). Approximately 11% of the marine fisheries production in Solomon Islands is from coastal subsistence fishing while the other 89% is from offshore and coastal commercial fishing (Gillett & Cartwright, 2010). Coastal subsistence fisheries production had an estimated value of $252SI million (~US$32 million) for 2014 (Gillett, 2016)

Most Solomon Islanders live in coastal communities, although there are considerable inland populations on some major islands (Hviding, 1998). Fishing is a main source of food and livelihood for the coastal communities. The fishing grounds in the Solomon Islands are owned by local people, under customary law regimes. Virtually all reefs are controlled communally by kin-based groups (lineages, clans or tribes), residing in areas recognized as theirs (Hviding, 1998). Unlike in Fiji, there is no legislated demarcated community fishing ground in Solomon Islands. This research was conducted only in the Western province in the Roviana and Vonavona lagoons and in three communities on the island of Rendova (Fig. 3.2). The Roviana and Vonavona lagoons are protected by offshore raised volcanic islands which are 20 and 40m high, respectively. There are villages on these offshore islands and also on the main land of New Georgia. The inhabitants of these villages are mostly engaged in fishing and they rely on reef resources for food and livelihood.

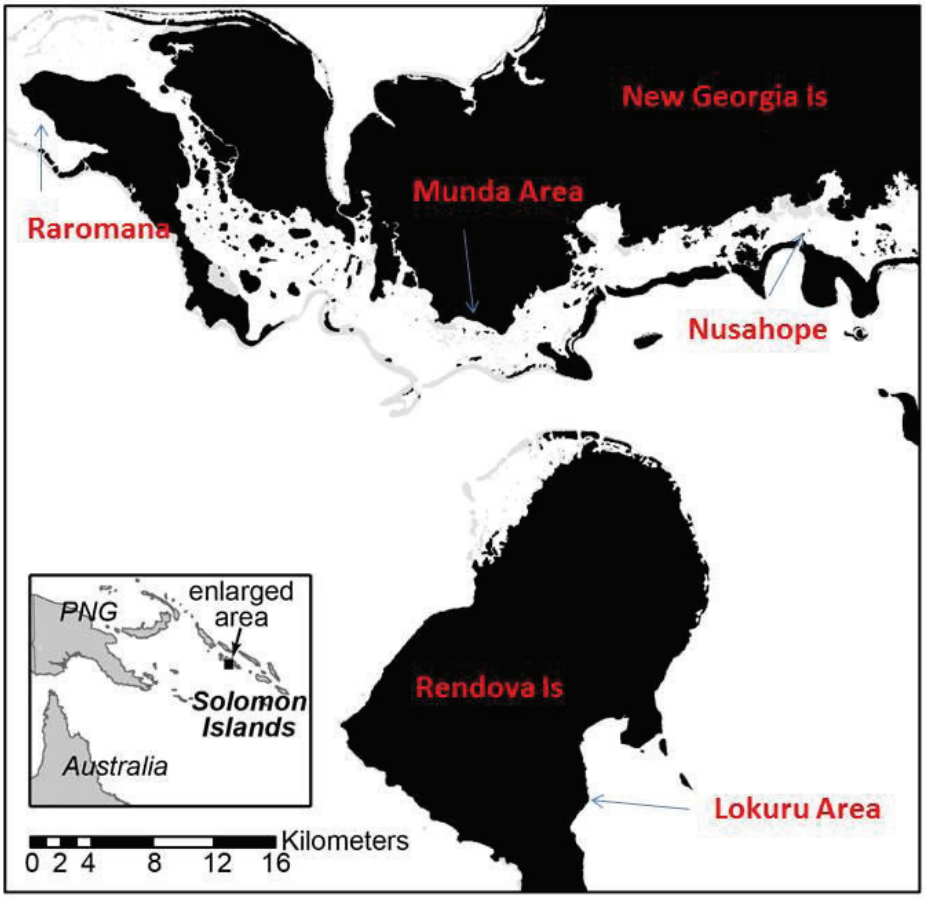

Figure 3.2: Map of Solomon Islands showing research sites

3.1.4.1 Munda area

Munda[3] consists of four communities: Dunde, Kekehe, Lodumaho and Kindu. Dunde and Kindu have more than 100 households while Kekehe and Lodumaho have smaller populations (Table 3.4). The four communities differ administratively. Each community has its own chief and village elders who control its land and sea estates (*pepeso*). In essence, the communities have kinship ties which have originated from a long history of intermarriage (Aswani, 1998). Any management of marine resources is the responsibility of the individual village chiefs and clans that are traditional owners of these resources.

The studied communities have access to agricultural land but households continue to fish for food and income. The presence of Soltai Tuna cannery near Munda provides work for some residents. The communities of Dunde, Kekehe and Kindu used to have *tabu* areas but all have been opened. The only community that has an existing, periodically harvested *tabu* is Kindu, where part of the mangrove is being protected for clam shells. The total number and percentage of households surveyed is shown in Table 3.3.

Table 3.3: Total number of households, number of households surveyed and percentage of surveyed households in Solomon Islands

Community	Total number of households	Number of household surveyed	% of households
Dunde	100	40	40
Kindu	100	42	42
Kekehe	50	29	58
Lodumaho	24	18	75
Nusa Hope	100	40	40
Raromana	100	40	40
Bagopingo	100	40	40
Vanikuva	33	24	73
Rano	30	17	57

3.1.4.2 Nusa Hope

The community of Nusa Hope is in the Roviana lagoon. People in Nusa Hope depend heavily on marine resources for food and livelihood. They have access to land but have to paddle canoes to reach their farms. Their produce is often sold at the Munda market on Friday but this journey could take more than an hour on a motor boat. They have an existing *tabu* area which is managed by the Roviana Conservation Foundation (RCF). The RCF is a local NGO that is working in association with the Roviana lagoon communities in marine conservation and sustainable rural development since the late 1990s (pers. comm. Shankar Aswani, 24/12/2013). It was established

[3] Munda is the second biggest town in Western province. The communities of Kindu, Dunde, Lodumaho and Kekehe surround this town and were generally referred to by people as Munda.

with the advice of foreign academic experts and funded by international donors (Aswani, 2007). According to community members in Nusa Hope, Dunde, Kekehe, Kindu and Lodumaho, RCF has not been functioning effectively for some time. The total number and percentage of households surveyed is shown in Table 3.3.

3.1.4.3 Raromana

The Raromana community is located by the Vonavona lagoon which is adjacent to the Roviana lagoon. Residents of Raromana fish for food and income and also have access to land for farming. They do not have an existing *tabu* and they depend heavily on marine resources and farming. The community is closer to Gizo, the biggest town in Western province and it takes approximately thirty minutes by boat with engine in favourable weather conditions. Most of the produce is sold at the market in Gizo. This community was one of the PROCFish sites that were surveyed by SPC in 2009. The total number and percentage of households surveyed is shown in Table 3.3.

3.1.4.4 Lokuru area

The Lokuru area on the island of Rendova consists of three communities, Rano, Vanikuva and Bagopingo. They rely on marine resources mainly for food. The communities sell most of their catch in the village and occasionally at Munda and Gizo markets. The communities of Lokuru are further away from Munda and Gizo and access to efficient transportation is a constraint for marketing their marine and land produce. Households have access to fertile land which is most used to farm a variety of crops. The communities are part of the Tetepare Descendants Association (TDA) which is responsible for looking after the island of Tetepare (the largest non-inhabited island in the South Pacific) which has an MPA. The total number and percentage of households surveyed is shown in Table 3.3.

3.1.4.5 Socio-demographic characteristics

The socio-demographic characteristics of the communities studied in Fiji are shown in Table 3.4. The total number of households surveyed in Solomon Islands was 289, with 267 fishers and 22 non-fishers. The sub-samples included more male than female respondents. Most of the respondents were within the age of 29-59 and more than 90% were married. The education level of fisher and non-fisher respondents were low with most respondents leaving the education system at the completion of either primary or secondary, and very few entered tertiary education, similar to household's respondents in Fiji. Most households own land while those that do not own land would ask landowning clans for land access. The majority of the households belong to the United Church while the other two churches common to the sites were the Seventh Day

Adventist (SDA) and Christian Fellowship Church (CFC). Christianity is the only religion that is widely practiced in all communities.

Table 3.4: Demographic characteristics of household respondents from Solomon Islands

	Fishers (N=267, 92%)		**Non-Fishers (N=22, 8%)**	
Variable	**n**	**%**	**n**	**%**
Gender				
Male	184	69	14	64
Female	83	31	8	36
Age				
18-28	20	8	1	4
29-38	65	24	2	9
39-48	65	24	9	41
49-59	71	27	3	14
>60	46	17	7	32
Marital status				
Married	237	89	20	92
Single	15	6	0	
Divorced	6	2	1	4
Widow/Widower	9	3	1	4
Education				
Primary	135	51	12	54
Secondary	113	42	5	23
Tertiary	19	7	5	23
Own land				
Yes	243	91	17	77
No	24	9	5	23
Religion				
United Church	136	52	17	77
SDA	49	18	1	4
CFC	49	18	1	4
Others	33	12	3	15

3.2 Research Strategy

3.2.1 Methodological approach

This study explores the livelihood options of coastal communities in the face of the different changes in reef resource availability and climate change. In order to document these changes it is necessary to understand how these communities perceive their reef resources and the different factors that affect these resources. To understand and evaluate the perception of communities, mixed methods (quantitative and qualitative) approach was adopted using structured household interviews, semi-structured key informants interview (KII) and focus group discussions (FGD). The lack of availability of natural science data due to financial constraints and the restricted time

for this study limits the researcher to focus on perceptions of resource change. Several studies have defined and used mixed methods approaches (Tashakkori & Teddlie, 2003; Johnson & Onwuegbuzie, 2004; Johnson *et al*., 2007).

As a methodology, mixed methods involve assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone (Creswell & Clark, 2007).

This study integrates the complementary design which combines quantitative and qualitative methods, where the results from one method were used to elaborate and enhance or illustrate the results from the other (Green *et al*., 1989). Green further states that this approach involves triangulation of data. Triangulation is the idea of looking at something from multiple points of view with multiple methods and/or data types which improves accuracy (Teddlie & Tashakkori, 2008)

Quantitative techniques were used to gather data on the different livelihood capitals households have access to, i.e. social, human, financial, natural and physical capitals. The survey was designed to elucidate how households have coped with, or adapted their livelihood options to, decreasing reef resources. Qualitative data was collected to understand local ideas on the changes in reef resources over past decades and the different local or global socio-economic factors that may have caused these changes. This is perception data, which focuses on people's understanding of what, how and why different changes have occurred (Creswell, 2003; Denzin and Lincoln, 2005; Silverman, 2011).

The first objective of this research is to firstly understand the different livelihood strategies households have and to quantify how dependent they are on reef resources. This led the researcher into understanding the relationship between dependence on reef resources and the different capital assets households have access to, which in turn would indicate sources of vulnerability for households and communities. The major assumption for this study is that households or communities who depend on reef resources as their main source of livelihood are vulnerable to a decrease in reef resources. The researcher also investigated what drives people to fish and how these drivers have affected the availability and abundance of reef resources. Therefore to answer the question on vulnerability and adaptive capacity, both quantitative and qualitative data were triangulated (Denzin, 2012).

As stated in Cameron (2011), a major challenge for researchers using mixed methods relates to the level of integration between qualitative and quantitative methods. Researchers who have used a mixed methods approach have used both qualitative and quantitative data collection but have analysed these in their own tradition (i.e. quantitative data analysed using quantitative methods and qualitative data analysed using qualitative methods) (Hurmerinta-Peltomäki & Nummela,

2006; Bryman, 2008) In this study the researcher analyses data separately using various analytical software programs, but the results were triangulated to answer the objectives of this research. Results were triangulated to gain an in depth understanding of the research subject (Teddlie & Tashakkori, 2008; Denzin, 2012) and cross-validated to reduce any bias from using only one single method (Denzin, 2012).

Sampling strategies

The sites for this study provide a spectrum of social and environmental conditions. Purposive sampling was used to choose case study sites (Bernard, 2006; Silverman, 2011). The criteria for selecting the study sites were discussed in Section 3.1.1. The communities in Fiji and Solomon Islands differ in size therefore household selection was carried out differently between the communities. In communities of fewer than 40 households, the researcher surveyed 80% of the households and an attempt was made to survey all households. In communities with more than 40 households, the researcher surveyed at least 40 households. Interviewees from each village were randomly selected to ensure a representative sample.

3.2.2 Data collection

Data collection in Fiji was from October 2014 to January 2015 and for Solomon Islands from February 2015 to May 2016. A second field visit to Fiji was conducted in June and July 2016. This visit was only to three of the study communities in Fiji, namely those who were greatly affected by the category five cyclone (Winston) that had struck the islands on 20th February 2016. The first field study included household surveys, key informants interviews, and focus group discussions. The second field study in 2016 was specifically to revisit the households that were interviewed in 2014 to gauge how they had coped or adapted after the cyclone. This re-survey used the same mixed method approach used in 2014.

The knowledge and social network that the researcher became part of while working for Wildlife Conservation Society (WCS) in Fiji and the Institute of Applied Science at the University of the South Pacific (USP) helped me in data collection in Fiji and Solomon Islands. WCS and USP facilitated my access to the communities with letters to the provincial offices requesting approval for my study in Fiji. In the Solomon Islands, a senior officer in the Ministry of Environment who was a colleague from USP assisted me in getting my research permit. The process of getting approval to work in Fijian communities is the same as in the Solomon Islands, where the communities that a researcher wishes to conduct research in need to give their approval before they can be visited. In Fiji this is very important and no research will be granted by the community if researchers enter the village without prior knowledge and approval of the provincial office and the *turaga ni koro* (village headman). In Fiji, the provincial offices obtain approval from the communities but in the Solomon Islands the researcher has to visit each community to formally ask the chiefs for their approval. This was done with the help of one of

the field assistants who is from Dunde to explain the purpose of the research to the chiefs. A signed document of approval by the chiefs is then taken to the provincial office to prove the community chiefs' approval for the research to be conducted in their community.

In Fiji, a *sevusevu* (formal presentation of dried root of *Piper methysticum*) has to be presented to the chief and elders of the village once a researcher arrives in a village, but no such formal presentation is required in Solomon Islands. In Solomon Islands the researcher was assisted by a local who had worked with a local NGO (RCF) and who had good knowledge and connections within the communities. His experience enabled easy access into these communities. In each community in Solomon Islands, the chief and village organizer had to be met, but this was done informally without any presentation. During the meetings with the chiefs and elders in Fiji and Solomon Islands, a detailed explanation of the research was given to get prior informed consent.

The researcher had two field assistants in Fiji and three field assistants in the Solomon Islands. A four day workshop was conducted to train the assistants so that they understood the objectives of the research and the way each question needed to be asked consistently. A trial run for the researcher and field assistants was carried out to test the questionnaire. Thorough discussions were held after the trial. All field assistants were university graduates, with one assistant from Solomon Islands being a former primary school teacher who had previously conducted socio-economic surveys. It was clarified with assistants that they should have no influence in the way respondents answer the questions. The first field research was conducted in Fiji because of the previous experience of the researcher in Fiji. This enabled the researcher to familiarize himself with the questionnaires and to improve on the survey instruments. There were some minor changes as to how the questions should be asked, which were adopted in both countries. Solomon Islands was the second country visited. The study was only conducted in Western Province due to the pre-existing information and network with one of the research partners, Shankar Aswani, who has previously worked in some of these communities.

3.2.3 Household surveys

A household was defined as people living together and sharing meals (Cinner & Bodin, 2010). Household surveys (HHS) have been incorporated into many studies for the purpose of collecting data which includes assets, demographic information, livelihoods, economic situations and infrastructure (Blythe *et al*., 2014; Cinner & Bodin, 2010; Combest-Friedman & Miles, 2012; Mills *et al*., 2011). Most studies on livelihood vulnerability have used HHS as their main tool for collecting data and results have been used to identify communities that are vulnerable to different stressors (Cinner *et al*., 2010; Cinner *et al*., 2012; Ellis, 2007; Fang *et al*., 2016; Feeny *et al*., 2013).

The first method used in the communities was HHS. Houses were randomly selected with the help of a village elder, where houses were numbered and entered in a list. Forty households to be

surveyed were randomly selected. For communities with fewer households, the researcher tried to interview all the households, but in each site at least half the households were surveyed. This was done consistently in both countries. Between 6-40 HHS per community were conducted, depending on the number of households in each community. The head of the household was interviewed. In both countries, the head of the household was always male, but where the eldest male had died, the female became the head of the household. If the head of the house was not available, his wife or an adult was interviewed. A household was revisited if there was no adult present or if no one was at home when first visited. The sampling approach was chosen to obtain the optimal amount of data in the available time. The questionnaire (Appendix A) was translated into Fijian for Fiji, and Pidjin English for Solomon Islands for the pilot survey. The pilot survey showed that it was most feasible to have the questionnaires in English, the reason being that translated questionnaires took away some meaning of the questions. All the HHS interviews were conducted in the local languages, i.e. Fijian in Fiji and Pidjin English in Solomon Islands. In Solomon Islands some respondents could not speak Pidjin, so a translator was needed to translate the questions into Roviana language or Lokuru language, but this was only for a few households. This did not affect the results as one of the field assistants spoke these languages fluently. For confidentiality it was recommended that only the household members are present in the house during questioning as the presence of other people may have had influenced the answer of the respondent (Bernard, 2006). Husbands and wives were encouraged to be present during the interview whenever possible. This provided the opportunity to validate answers that were given by the respective household members. For example in some communities in Solomon Islands, the questions on farming were mainly answered by women, even when men were present, since they mainly engaged in farming. After each day the researcher and the assistants would sit together to discuss issues and to monitor entries by assistants.

3.2.4 Selection of key informants

Key informants are people within the community that have a broad knowledge and thorough understanding about the issues and topics that are studied (Morse, 1998). Key informants, as a result of their personal skills or position within a society or community, are able to provide more information and deeper insights into what is going on around them (Marshall, 1996). These could be just ordinary people and not necessary specialists, the well-educated, those in power or officials (Mckenna & Main, 2013). The ideal key informant as described by Marshall (1996) and Tremblay (1957) should have the following characteristics:

- *Role in community:* their formal role should expose them to the kind of information being sought by the researcher
- *Knowledge:* In addition to having access to the information desired, the informant should have absorbed the information meaningfully

- *Willingness:* The informant should be willing to communicate their knowledge to the interviewer and to co-operate as fully as possible
- *Communicability:* The informant should be able to communicate their knowledge in a manner that is intelligible to the interviewer
- *Impartiality:* The informant should be objective and unbiased

Key informants with specific knowledge and understanding could provide insights on the nature of the issues being researched and give recommendations. The key informants for this study were selected using these characteristics above. The key informant in each community was selected after consultation within the community. Key informants chosen in this research met at least three of the criteria mentioned above and provided in-depth information.

Key informant interviews (KIIs)

In this study, 11 key informants, 5 for Fiji and 7 for Solomon Islands were interviewed. The principle of prior informed consent was followed to identify key informants. Once the key informants were identified and selected, they were asked if they were willing to participate in the interview. Once there was an agreement, a time and place was scheduled for the interview. Most of the interviews took place at the key informant's residence. The interview lasted between 45 minutes and 1 hour and all the interviews were conducted in the local language, Fijian or Pidjin English. An introduction was always done prior to the interview informing the key informant as to why the interview was important to the researcher. During this process the informant was assured that all information collected would be kept confidential and anonymous.

The key informants were interviewed using a semi-structured questionnaire with general themes with open ended questions (Perecman & Curran, 2006). Questions covered topics on perception of reef resources, reef resource use, fishing gear, resource management, social dynamics (power, decisions, and conflicts), presence of key infrastructure and adaptation to changes both in the past and present (Appendix B). Once a question was asked, other questions evolved which gave the researcher the opportunity to go into more depth in discussions. All interviews were recorded with a digital voice recorder with the consent of the informant.

3.2.5 Focus group discussions

Focus group discussions (FGDs) are a data collection technique used by researchers to generate discussion amongst people involved in the focal issue (Kitzinger, 1994; Morgan, 1996; Bernard, 2006). FGDs allow for interaction and detailed group discussions, which in this case permits the researcher to observe group dynamics where a consensus is being worked out. An ideal focus group should have 6-12 members, plus a moderator (Bernard, 2006). If the group is too small it could be dominated by one or two participants, and if it comprises more than 10-12 it would be difficult for the moderator to manage (Bernard 2006). The researcher should be the moderator steering the direction of the discussions and should also be in charge of the decision-making

process (Bernard, 2006; Kitzinger, 1995). Everyone in the FGD should be involved in the discussions; therefore good facilitation skills are required from the researcher to inspire everyone to be involved (Morgan, 1996; Silverman, 2011). Bernard (2006) referred to a moderator needing the combined skills of an ethnographer, a survey researcher and a therapist.

Focus group discussions disclose a wide array of perceptions that different people have on the issues discussed (Silverman 2011). FGDs were used in this study to check the validity of responses from the household surveys and key informants' interviews and to provide more in-depth knowledge of the issues (Ward *et al*., 1991 in Bernard 2006). They provided insights and discussions amongst participants, where disagreements on some questions gave the opportunity to the researcher to develop a holistic answer that included contributions and knowledge from all.

In each of the communities studied, the researcher conducted one FGD for men and one for women. This was done because in the cultural context of Melanesia, women cannot express themselves easily during a community meeting where males are present, but have the liberty to voice their ideas during household interviews. Most communities in Fiji and Solomon Islands are male-dominated during meetings where important issues are discussed and decisions are made. In some communities, women were actively involved in meetings and decision making. With women being a significant part of the fishery, their views, knowledge and perceptions were important. There were 5-7 participants in each focus group and a requirement was that all participants have a good knowledge and understanding on fishing and also farming.

Morgan (1996) indicates that FGDs may involve fewer logistical activities and reduce the amount of travel and time that is required by the researcher but this was not the case for this research as a lot of time and logistics were needed to get participants for FGD. The researcher had to find a time that was convenient for all the participants. In some communities in the Solomon Islands due to the distance between households, a truck was needed to pick up and drop participants for the focus groups. The principles of prior consent were followed whereby the reasons for the FGD were thoroughly explained to each chosen participant beforehand. Incentives were used to inspire the participants to actively participate in the discussions (beetle nut, cigarettes and snacks).

Once the group met in the designated place, the aim and objective for the discussion was explained to the participants, reassuring anonymity of their answers and requesting their permissions for the discussion to be recorded on a voice recorder. It was important to create an environment where all participants felt comfortable and relaxed to maximize interaction and participation in group discussions (Perecman & Curan, 2006; Bernard 2006). A set of open-ended questions with two themes: (i) resource use and (ii) adaptation and coping strategies used by people were used to guide the discussions (Appendix C). The same themes and questions were use used for both male and female focus groups.

A limitation of FGDs was that a few participants may dominate the discussions if there is lack of control from the facilitator (Kitzinger 1995, Bernard 2006, Silverman 2011). This situation was controlled by encouraging silent participants to answer by specifically directing the question to them. Once the participants began to adjust to the group, they would actively participate in discussions. The FGDs took one and a half to two hours in each community.

3.3 Data Analysis

3.3.1 Qualitative data

All the recorded key informant interviews were translated into English and transcribed. The data from Solomon Islands was transcribed by one of the field assistants and for Fiji the data was transcribed by the researcher. All the answers from the interviews and FGDs were transcribed and grouped according to the themes which were deducted from the results of FGDs and KIIs. MAXQDA 11 software was used to code and analyse the data. A deductive coding approach was used since the researcher was trying to answer specific questions (Bernard 2006). Deductive coding is the coding of qualitative data where codes based on theories are developed based on previous research. While reading through the text, common issues that arose were given specific codes under each theme (Silverman 2011). Simple codes were used for the purpose of this study where broad themes and common issues from the analysis were recorded.

After the codes were developed and the texts coded, summaries of each theme were prepared which identified key issues. These key issues were correlated with findings from the household data which was analysed quantitatively. These codes were then interpreted using a hermeneutics approach where the researcher tries to bring in his subjective, interpretive ideas to the text and develop an understanding of how each of the parts relates to the whole (Neuman, 2011). The reason this approach was used was to relate the different parts of the code to the main issue which reveals a deeper meaning and understanding of the issues being studied. The researcher was able to visualize how the different codes and themes relate to each other by linking the themes to the research objectives. Direct quotations from respondents were used with anonymity in parts of the thesis. Photos taken during the research were also used to illustrate specific facts about the study areas.

3.3.2 Quantitative data

The quantitative data collected through household hold surveys were entered into a spreadsheet in Microsoft Excel (Microsoft Corporation 2010) by the researcher and field assistants and checked for inconsistencies. This data were then coded into a format in which it could be analysed statistically. After coding, the file was exported to IBM SPSS statistics software for analysis.

3.4 Analysis for drivers of reef resource use in Fiji and Solomon Islands

Household structured interviews; semi-structured key informant interviews and focus group discussions were used to gain accurate insights into the drivers of reef resource use in Solomon Islands and Fiji. Most of the data analysed were from FGDs and key informants interviews. The key informant interviews commenced with questions on reef resources such as the type of fish targeted, the gear used, distance to the nearest market and the price of fish. During key informants and FGDs, respondents were asked to identify the reasons why they fish and were given time to elaborate and openly discuss their thoughts. FGDs focused on long term trends and changes in: 1) reef resource use, 2) fishing gear, and 3) price of fish and market development. Household surveys included questions on demographics, expenditure, diversity of fishing gear and the number of family and community events households are engaged in. The researcher determined the percentage of fish sold or bartered during the HHS by asking respondents the different species of fish they normally catch, the number of fish they would catch in a typical fishing trip and the number of fish that would be sold in the market. This would distinguish between subsistence fishers and those that sell their catch. Social-demographic information on education level, religious groups and population were extracted from HHS and presented in Tables 3.4 and 3.9. Drivers of fishing were grouped using a framework developed by (Kittinger *et al.*, 2012) and adapted by Hicks *et al.* (2016). Key informants interviews and FGDs were analysed using MAXQDA 11 while HHS were analysed in IBM SPSS 23.

3.5 Analysis methods for characterizing livelihood vulnerability and adaptive capacity of communities in Fiji and Solomon Islands

3.5.1 Exposure

There were two indicators used in the assessment of exposure in this research: 1) perception of reef resources of households; and 2) predicted year of coral bleaching aggregated for sites. The data on reef resource perception and the predicted year for coral bleaching were used in the calculation of the exposure index for communities.

The exposure index in this study was derived by asking household respondents whether they perceived fish in their fishing grounds to be increasing or decreasing in the past 5-10 years and consulting existing data predicting the year coral reefs at each community are expected to bleach. Other studies have used ecological data to calculate exposure index based on climate change effects on marine resources (Cinner *et al.,* 2012; Cinner *et al.,* 2013; Marshall, *et al.,* 2013). For the hypothetical question on the perceived abundance of fish in their fishing grounds, respondents were given choices whether reef resources were increasing, decreasing or had remained the same.

The predicted years for coral reefs to bleach for the study sites in Fiji and Solomon Islands were calculated from the Coral Reef Watch website ("Coral Reef Watch," 2017). There were four

scenarios used in the calculation of the predicted year corals are expected to bleach (Table 3.5). The protocol for downloading the data can be found in (Appendix D). For the purpose of this study, scenario 1 was used because it had a wide range between the years for all the communities using regression. The expected years for corals to bleach were bounded between 0 and 1 (0 = least exposed and 1 = most exposed). This was done by taking the inverse of the data, setting the highest year at zero and the lowest year at 1. Based on this, the values for coral bleaching were calculated for all the communities. Perception of resources and coral bleaching were weighted equally in the calculation of the exposure index. The equation below was used to calculate the exposure index of communities.

$$E = \frac{\left[\left(\frac{D}{T_{HH}} - \frac{I}{T_{HH}}\right) + CB\right]}{3} + 1/3 \quad (Equation\ 1)$$

Where E = exposure, D = number of households that mentioned decrease, I = number of households that mentioned increase, T_{HH} = total number of households, CB = coral bleaching value calculated from the predicted year of corals to bleach. The range for household perception is from -1 to 1 and coral bleaching from 0 to 1 and they were equally weighted. To achieve an exposure index bounded between 0 and 1, the combined value was divided by 3 and further adjusted by adding 1/3. The index for exposure was calculated using the above equation for each community.

Table 3.5: The four different scenarios used in the extraction of the expected year for corals to bleach.

Scenarios	Description
1	Year by which bleaching will happen 10x per decade (i.e. annual bleaching); under scenario RCP4.5 which assumes emissions stabilize just after 2100 due to successful implementation of climate policies that reduce emissions.
2	Year by which bleaching will happen 2x per decade; under scenario RCP4.5 which assumes emissions stabilize just after 2100 due to successful implementation of climate policies that reduce emissions.
3	Year by which bleaching will happen 10x per decade (i.e. annual bleaching), under scenario RCP8.5 which assumes no climate policies are adhered to (i.e. business-as-usual)
4	Year by which bleaching will happen 2x per decade, under scenario RCP8.5 which assumes no climate policies are adhered to (i.e. business-as-usual)

Source: https://coralreefwatch.noaa.gov/climate/projections/downscaled_bleaching_4km/index.php

3.5.2 Sensitivity

Sensitivity was calculated based on the level of dependence of households on reef resources (Allison *et al*., 2009; Cinner *et al.,* 2012). The assumption was that the higher the dependence of

communities on reef resources, the higher their sensitivity as reef resources decreases. Respondents from household interviews were asked to list all livelihood activities that bring in food or income and rank them in order of importance. Occupations were grouped into the following categories: fishing, farming, gleaning, cash crops, salaried employment, informal economic activities and other. The researcher adopted the groupings used in Cinner *et al.,* (2012) where gleaning, fishing and marketing of marine products were grouped as 'fisheries' and all other activities as 'non fisheries' sector. Sensitivity was calculated using Equation 2 ,which incorporates the proportion of households engaged in fisheries, whether these households also engage in non-fishery occupations (link between the two sectors) and the directionality of the linkage (whether respondents ranked fisheries more important than non-fisheries sector) (Cinner *et al.*, 2012):

$$S = \frac{F}{F+NF} \times \frac{N}{F+NF} \times \frac{\left(\frac{r_{fn}}{2}\right)+1}{r_{fn}+r_{nf}+1} \qquad \text{(Equation 2)}$$

where S = sensitivity, F = number of households relying on fishery related occupations, NF = number of households relying on non-fishery related occupations, N = number of households, r_{fn}= number of times fishery related occupations were ranked higher than non-fishery occupations (normalized by the number of households), r_{nf}= number of times the non-fishery related occupations were ranked higher than fishery related occupations (normalized by the number of households). The first term in the equation captures the ratio of fishery to non-fishery related occupations. The second term captures the extent to which households dependent on fisheries also engage in non-fisheries livelihood activities, and this decreases the sensitivity when households are engaged in multiple livelihood activities. The third term captures the directionality of linkages between fisheries and non-fisheries such that communities were more sensitive when households engaged in fisheries and non-fisheries consistently ranked the fisheries sector as more important than other livelihood activities (Cinner *et al*., 2012:14)

3.5.3 Adaptive capacity

The adaptive capacity index was developed by incorporating indicators used in McClanahan, *et al*. (2008) and Cinner *et al.* (2013). These indicators were based on the ability of households to anticipate and respond to change using the SLF. Based on these two studies and results from household surveys and key informant interviews, the researcher derived twelve indicators to measure adaptive capacity. These indicators were grouped into the different assets (social, physical, human, natural and financial) under the SLF (Table 3.6). The adaptive capacity indicators were obtained from household survey interviews and this was complemented with direct observation, key informant interviews and focus group discussions.

Table 3.6: Indicators of social adaptive capacity

Sustainable Livelihood Asset	Indicator	Description	Bounding
Social	Trust	measured as an average to Likert scale responses to questions about respondents' trust in community members, local leaders, religious leaders, NGO, police, government and people outside the community	Continuous: min = 1; max = 5.33
	Community network	measured by the number of community groups or committee the respondent is engaged with	Continuous: min = 1; max = 3
Physical	Material style of life	a material style of life indicator based on possession of electricity, TV, sanitation, piped water, etc. measured by factor analysis using principle components analysis	Continuous: 1st quartile = 1; 3rd quartile = 3
	Infrastructure	measured by factor analysis of 20 infrastructure items	Continuous: min = 0; max = 20
	Gear diversity	measured by the diversity of fishing gear used by each household	Binomial: 0 = 1 gear; 1 = more than 1 gear
Financial	Access to credit	measured by whether respondent felt he/she can access credit through formal institutions or formal means	Binomial: 0; 1
	Debt	measured by whether the respondent was presently in debt, defined as owing more than one week's salary	Binomial: 0 = in debt; 1= not in debt
Human	Human agency	measured by content organizing responses to open-ended questions about what could impact the number of fish in the sea	Binomial: 0; 1
	Occupational multiplicity	total number of person-jobs in the household	Continuous: 1st quartile = 1; 3rd quartile = 3
	Occupational mobility	measured by whether the respondent has changed jobs in the past five years and preferred their current occupation	Binomial: 0; 1

	Capacity to change	measured by content organizing responses to a hypothetical 50% decline in fish catch	Binomial: 0; 1
Natural	Access to land	Measured by whether respondents have access to or own land	Binomial: 0; 1

The vulnerability index was calculated using the formula:

$$Vulnerability = \frac{Exposure + Sensitivity + (1 - Adaptive\ Capacity)}{3} \quad \text{(Equation 3)}$$

Source: (Allison *et al.,* 2009; Cinner *et al.,* 2012)

The indicators chosen for the calculation of the vulnerability index were based on household surveys which could cover household demographics and livelihoods activities, perception about resource conditions and occupational changes. The values of exposure ranged between 0 and 1 for all communities. The values close to 0 shows low exposure while values close to 1 shows high exposure. Sensitivity and adaptive capacity index ranged between 0 and 1 with values close to zero having low sensitivity and adaptive capacity and values close to 1 shows high sensitivity and high adaptive capacity. The vulnerability index was calculated to range between 0 and 1 for all communities, with values close to zero demonstrating low vulnerability and values close to 1 demonstrating high vulnerability of communities.

This study used composite indicators to measure the adaptive capacity of households and communities. Composite indicators are formed when individual indicators are compiled into one single index which then measures multidimensional concepts that cannot be measured by a single indicator (Nardo *et al.*, 2008). These indicators summarize complex dimensions of a reality and can support decision-makers, are easy to interpret, facilitate communication with a general audience, and enable users to compare complex dimensions effectively (Maldonado & Moreno-Sanchez, 2014). The questionnaire was designed to provide the information needed to calculate the indicators and the index. To be able to compare and aggregate the indicators, indicators were normalized and bounded. The bounding used for each of the indicators was to allow for each indicator to capture the largest possible variation in the original data. Therefore if the variables did not have much variation within the communities, then the minimum and maximum would not be evocative as bounding. Using these variables would reduce or amplify the variation in the normalized indicator and its relative importance to other indicators when combined. All indicators were weighted equally within each dimension which implies that all variables have the same relevance in the composite. A separate analysis of individual adaptive capacity indicators was conducted to determine their contribution in the adaptive capacity of households and communities.

3.5.3.1 Social assets

The social assets indicators included quantitative data on involvement of households in community organizations, decision making and their level of trust (Pretty & Ward, 2001; Cinner *et al.,* 2009). Respondents were asked if they belonged to a community organization and whether they were involved in any decision making. Those who had been involved were asked how many organizations or committees they were involved in. They were also asked if they actively[4] or passively participated in meetings.

3.5.3.2 Man-made physical assets

Indicators of physical assets included quantitative data on material style of life (MSL), community infrastructure (Pollnac and Crawford, 2000) and fishing gear diversity (Cinner *et al.* 2012). MSL was also used in this study to capture the relative wealth of households (Cinner & Pollnac, 2004). To determine MSL of a household, a list of indicator items was used (Appendix A). These items were recorded as present or absent. Key informants and participant observations provided information on the presence of key community infrastructure such as primary and secondary schools, hospitals, medical clinic, doctors, dentist, nurses, piped water, sewage pipes, sewage treatment, septic tanks, food markets, pharmacy, guest house, public transport, roads, bank, gas station, telephone and electricity (Cinner *et al.,* 2012).

3.5.3.3 Financial assets

Respondents during the household interviews were asked whether they have access to credit. If they responded that they could access credit, they were asked to state from where. They were also asked if they were in debt of more than a week's wage or salary.

3.5.3.4 Natural assets

The indicator for natural assets was a question to the respondent during the household survey whether he/she owns a piece of land or not. If the response was "no", he was further asked if he has access to use of land by landowners.

3.5.3.5 Human assets

The indicator sets used were: human agency, capacity to change, occupational multiplicity and occupational mobility (Cinner *et al.,* 2012). To capture human agency, respondents were asked an open-ended question on what could impact the number of fish in the sea. The rationale was to determine the knowledge respondents have on the different threats that could affect the

[4] Actively participate meaning they attend community meetings and speak.

abundance of fish. Responses were grouped into categories such as overfishing, nets, night diving, traditional fishing, climate change, logging, pollution and over population. Respondents were asked how they would respond to a 50% decrease in catch as a means of capturing their capacity to adapt (Cinner *et al*., 2012). There were different options in this question such as "continue fishing same amount", "move location", "change gear", "fish less", "fish harder" and "leave fishery". Those that mentioned they could leave fishery were categorised as having the capacity to change. To determine occupational mobility, respondents were asked whether they have changed jobs in the last five years and if preferred their new job. Occupational multiplicity was captured by asking how many different occupations brought food and income to the household.

3.5.4 Data analysis

A principal component analysis (PCA) was run separately for communities in Fiji and Solomon Islands on the 12 indicators of adaptive capacity to highlight any observed relationship using Primer 6+ software (Clarke and Gorley, 2015). PCA has been widely used by social scientists for the construction of indices (Cinner, 2010). A correlation test was run on the adaptive capacity indicators to show whether there was high correlation among the twelve indicators. There was no significant correlation in the adaptive capacity indicators therefore all were used in the analysis. Since the data failed the normality test (data was not normally distributed) and homogeneity variance (the number of samples differ for all communities), PERMANOVA was conducted to capture if there was any significant difference between the countries and the communities on the adaptive capacity indicators. A permutational cluster analysis using SIMPROF was then used. This was done to combine similar communities together and test the significance of these groupings. These statistical tests were run using Primer 6+ software.

A PCA was run separately for Fiji and Solomon Islands for the five different assets. The indicators for the five livelihood assets (Table 3.6) were summed and the average for each asset was used in the analysis. These indicators were not weighted.

A PCA was also run for factor analyses of the 56 MSL indicators for Fiji and Solomon islands using the varimax rotation (Pollnac & Crawford, 2000). PCA is a variable-reduction technique used to reduce a larger set of variables into a smaller set of artificial variables that account for most of the variance in the original variables (Laerd Statistics, 2015). Results from the observed scree plot allowed for the first two components to be retained. This resulted in the retention of 25 components which was analysed. The same was done for the analysis of MSL within the countries. A T-test was conducted to determine whether there were significant differences between households in Fiji and Solomon Islands. Chi-squared tests were used to test for differences among communities in Fiji and Solomon Islands in perception of resources and fishing gear distribution. A Kruskal-Wallis non-parametric test was used to test for significant differences among communities in Fiji and Solomon Islands in ranked data (dependence on reef

resources and gear diversity) and Likert scale data (trust). These statistical tests were run using IBM SPSS Statistics 23. Qualitative data collected using focus groups and key informant interviews were used to support and further explain the analysed household questionnaire data.

3.6 Analysis for adaptation and transformative strengths of communities and households to exit a declining fishery in Fiji and Solomon Islands

3.6.1 Exit fishery

Only fishing households were used in this analysis. From the 246 households surveyed in Fiji and 289 households in Solomon Islands, there were 189 fishing households in Fiji and 270 in the Solomon Islands.

Twelve socioeconomic indicators were used to determine the reasons fishers would exit a declining fishery. It was hypothesized that these indicators could either cause an increase or decrease in reef resources. For example, high infrastructure could indicate that households could exit the fishery and have access to other livelihood options, leading to an increase in reef resources. A high MSL could show that households are wealthy and could exit the fishery, but if fishing is the main source of income, exiting the fishery might not be an option. Indicators used were selected based on previous studies (Cinner *et al.,* 2008; Daw *et al.,* 2012). The socio-economic indicators used in this study were: material style of life, land ownership, occupational multiplicity, fishing as primary source of food and income, non-fishery activities was primary source of food and income, age, education level, fishing experience, perception of fishery resources, infrastructure, and occupation mobility and fishing gear (Table 3.7).

There was a combined PCA for Fiji and Solomon Islands as well as separate PCA's for both countries. This was done to compare the wealth of households between countries and within countries.

Respondents were asked the amount of fish that they would catch on a normal day and this figure was used to construct hypothetical scenarios involving a reduction in catch (Cinner *et al.,* 2008). Respondents were asked what they would do if there was a 20% and 50% decrease in catch. Responses were recorded as: keep fishing the same amount, fish harder, fish less, move locations, change gear or leave fishery. Respondents that mentioned leave fishery were then asked what livelihood activity they would engage in when they leave the fishery.

3.6.2 Prevention measures to address decreasing reef resources

The perceived prevention measures stated by households were examined by asking the household respondents what could be done to increase the number of fish in the sea. Responses were grouped into different categories for each country as mentioned or not mentioned. A factor

reduction using principal component analysis was conducted separately for Fiji and Solomon Islands to determine which of the causes of reef resource decrease could be compared between the respective communities.

3.6.3 Data analysis

After evaluating the responses to 20 and 50% declines in catch, the researcher focused the on the responses to a 50% decline for a more comprehensive analysis. The researcher used three types of analysis to identify site, household and individual level factors to predict the stated response to a 50% decline in fisheries following Daw *et al.,* (2012). The different factors used in these analyses are provided in Table 6.1.

3.6.4 Classification tree model

The classification tree model was used to compare the predictive ability of factors at individual, household and site level. The univariate tree model was used because it was non-linear and it does not require the *a priori* interaction terms in the model (Zuur *et al.,* 2007). The classification tree was run using the site as a nominal variable to compare the predictive ability of individual and household factors compared to the site the respondent lives in (Daw *et al.,* 2012). The different factors assessed in this model would give a precise indication of which factors allow households to respond in a certain way when reef resources decrease whether to keep fishing or exit fishery. The regression trees and bivariate plots were used to determine the proportion of fishers that would exit at each site.

3.6.5 Multiple regression

A multi regression model was developed to assess whether individual or household level variables predicted the variation in the responses. Prior to launching the multiple regression model, the numerical independent variables were checked for pairwise correlation to avoid multicollinearity of the final regression model, using the Hmisc package's rcorr function in R (R Development Core Team, 2015).

To check for curvature in the relationship between the numeric predictors and the response variable, a generalized additive model (GAM) was first fitted to the data using the mgcv package in R (R Development Core Team, 2015). This would show a lack of correlation between the numeric predictors and response variable. The final multiple regression model was set up as a generalized linear model (GLM), with family = binomial and link = logit. All explanatory variables that showed signs of curvature in their relationship with the willingness to exit the fishery in the GAM model were equipped with a quadratic term in the maximal GLM model. With the data set holding 459 entries, and in light of the requirement to have at least 10 data points per parameter, the statistical modelling could not start with a maximal model of all

explanatory parameters, the curvature terms identified above, and all interaction terms included. Therefore interactions were left aside at first and only all explanatory parameters and the curvature term of those numerical parameters identified curved with the GAM model were included. The non-significant curvature terms were then consecutively removed. Once a model was produced that included significant quadratic terms only (or none), the interaction terms were then added.

Province and total number of gears were not included into the maximal model from the start, since both were entirely explained by other parameters in the model. Province was a function of country and community, and the total number of gears was the sum of all gears listed by respondents

Prior to the actual multiple regression modelling, the researcher referred to the classification tree model to assess the interaction structure of the data. Also, with the parameters remaining after cross correlation analysis, an exploratory general additive model was fitted to the data, to check for potential curvature of the responses. A potential curvature in the data was detected in the relationship between the response variable and fishing experience of the interviewees, and of the catch expected on normal condition days, but not for material style of life. Thus quadratic term for these respective terms was included into the maximal model for GLM modelling.

Fitting and stepwise reducing a GLM model with all single independent variables and quadratic terms for MSL, normal catch, and fishing experience led to all quadratic terms being removed from the model, since they did not deliver a significant contribution to the explanation of why respondents chose to exit the fishery. This led to a stepwise deletion of the simple, non-interaction terms from the model, if the variable was not significant. The only factors that remained for the final, simple, model were community, fishing as main source of food and income, perception of fisheries, speargun, trawling, and normal day catch.

With the model being reduced to significant simple linear relationships only, the significance of two-way interactions between these factors was tested. The maximal model for this included all two-way interactions between community, fishing as main source of food and income, perception of fisheries, speargun, trawling, and normal day catch, plus the simple terms themselves. However, such a model would lead to perfect separation, i.e. the predictors would explain the data ‘too well and inflate the coefficients, such that the resulting model is corrupted. Therefore, forward model selection was applied, meaning that, starting from a model holding the simple linear terms above only, two-way interaction terms were added a piece at a time. Significant interaction terms remained in the model and non-significant ones were removed. Additionally, the current model was compared to the minimal one (which was the minimal adequate model of the earlier exercise) using Chi-squared tests, and the interaction term removed when no significant differences in model performance were found. This showed that no interaction term was able to significantly improve the model’s performance, except for perception of fisheries: speargun, which, however, was not significant in the model, and was thus omitted.

Table 3.7: Factors that allow fishers to make particular choices to exit a declining fishery (Cinner *et al*., 2008; Daw *et al.,* 2012)

Scale	**Factor**	**Description**
Individual	Age	Age of respondent
	Education	Education level of respondent (primary, secondary or Tertiary)
	Fishing Experience	Number of years of fishing experience
Household	Type of fishing	Types of fishing gear used
	Catch	Perceived catch on a poor, normal and good day
	Perception of fisheries	Perceived abundance of fish in the sea
	Wealth	PCA of household MSL for entire country
		PCA of household MSL for each country
	Household occupational structure	Number of occupations in the household
	Role of fishing on household livelihood	Whether fisheries is the top ranked livelihood activity in the household
	Occupational mobility	Respondents that have changed their jobs in the past 5 years and preferred their new occupation
	Land	Respondents own land or not
Community	Infrastructure	Factor analysis of presence of 20 infrastructure items

3.6.6 Impacts of cyclone Winston on households in the communities of Tuatua, Nakodu and Natokalau

On 20 February 2016, a category 5 tropical cyclone Winston struck Fiji with winds up to 185mph and gusts of 225mph. This was reported to be one of the largest cyclones Fiji has ever experienced (Chaston *et al.,* 2016). The cyclone left a trail of destruction which affected most communities around Fiji. The communities of Nakodu, Tuatua and Natokalau which were the study sites for this research were affected severely. According to Mangubhai (2016), 100% of homes in Nakodu and Tuatua were either destroyed or damaged and 80% of homes on Ovalau[5] were damaged or destroyed. The three villages were revisited in June and July 2016 to ascertain ways in which communities had coped with or adapted to the destruction brought by Winston. The three communities during the previous survey in 2014 mentioned that they relied mostly on land as their main source of livelihood. Since most of the crops were destroyed by the cyclone, the assumption was that households would rely on reef resources as a source of livelihood.

Households surveyed in 2014 were resurveyed for comparison before and after the cyclone. More than 80% of the households were resurveyed. There were 33 households resurveyed in Tuatua, 31 households in Nakodu and 38 households in Natokalau (Appendix D). In Tuatua and Nakodu, some households could not be resurveyed due to their houses being completely destroyed and the members having moved to the capital, Suva. In Natokalau, the four households that could not be resurveyed were away in Suva for family reasons. The respondents were asked what they had lost which included persons, house, fishing gear and crops (Appendix E). Respondents were also asked to rank the impact of the loss on household economy. Respondents were then asked to describe what was done to cope with their losses and to rank whether the coping or adaptations were successful or not (1 not successful – 5 extremely successful). Lastly, respondents were asked the sources of strength for their household to cope with the cyclone.

[5] Ovalau is the island where the community of Natokalau is located

4 Chapter 4: Drivers of Reef Resource Use in Fiji and Solomon Islands

4.1 Introduction

The South Pacific has one of the largest areas of coral reefs in the world (Spalding, *et al.,* 2001), 2001). Most coastal communities in the region depend directly on marine and reef resources to provide a bulk of their protein (Johannes, 1981; Bell *et al.,* 2009) and also as a direct source of livelihoods (Kronen *et al.,* 2010). Reef resources provide ~50% of coastal households with their first or second income, obtained by selling surplus fish and invertebrates (SPC, 2008; SPC, 2014). Coastal communities in Pacific Island countries have one of the highest rates of consumption of seafood in the world, with fresh fish dominating their diet (Bell *et al.*, 2009). However, small-scale subsistence fisheries in the Pacific are diverse and are certainly not limited to reef-associated species only (Dalzell *et al.,* 1996).

There is a rising concern about the decreasing catch rates affecting many coastal communities in the Pacific (Gillett & Cartwright, 2010). The decrease is a result of changes in the marine ecosystem brought about directly or indirectly by natural or human-induced factors that are referred to as "drivers" (MA, 2005). Natural scientists, social scientists and SES scholars working in marine and coastal ecosystems differ in how they conceptualize "social", "human" and "anthropogenic" drivers of ecosystem change (Breslow, 2015). Many natural scientists focus on large-scale anthropogenic impacts on the natural environment. These relate mostly to factors such as human population density (Dulvy *et al.,* 2004; Halpern *et al.,* 2008; Hughes *et al.,* 2003; Jennings and Polunin, 1996), fishing pressure (DeMartini, *et al.,* 2008; Halpern *et al.,* 2008; Jennings and Polunin, 1996), pollution, and climate change (Halpern *et al.,* 2008; Hughes *et al.,* 2003). By contrast, Fulton *et al.* (2011) locate human drivers in the behaviour of individual managers and users of natural resources, who are responding in turn to micro-scale drivers of human behaviour related to employment, profit maximization, social status and lifestyle preferences. Human drivers of environmental change can also be conceptualized as social drivers; in this case the focus is on the underlying social, cultural, economic, institutional, legal, political and historical forces that enable and constrain human activities and motivations (Breslow, 2015). The distinction between approaches focussing on individual and those focusing on social drivers of socio-ecological change is critically important because different framings suggest different solutions (Breslow, 2015). It is important to understand that in this context, 'drivers' are not only those that affect ecological change but also socioeconomic changes.

The Millennium Ecosystem Assessment (MA, 2005:64) uses a more comprehensive approach that distinguishes between "direct" and "indirect" drivers. "A direct driver unequivocally influences ecosystem processes while an indirect driver operates more diffusely, by altering one or more direct drivers". The report identified five indirect drivers of change in ecosystem services, including "demographic, economic, socio-political, scientific and technological, cultural and religious" drivers (MA, 2005:64). These influence the "direct drivers", whose effect on the environment can be identified and measured, and which are "primarily physical, chemical

and biological, such as land cover change, climate change, air and water pollution, harvesting and the introduction of alien species" (MA, 2005:67).

Similarly, social scientists working on human-environment interactions often differentiate between proximate (direct) and underlying (distal) relationships (Kittinger *et al.,* 2012). When these relationships are negative they give rise to proximate and distal drivers of environmental degradation (Geist & Lambin, 2002; Kramer *et al.,* 2009). Proximate drivers refer to human activities at the local level (e.g. fishing pressure) which result in an ecosystem change, while distal drivers comprise the fundamental social and natural processes (e.g. human population dynamics, policies, markets, or culturally embedded attitudes and beliefs) that underpin the proximate drivers. Distal drivers can either operate at the local level or operate at national or global levels and have local-level impacts (Geist & Lambin, 2002). At the proximate level, social systems interact directly with resources, including ecosystem services; impacts affect the coastal societies that derive benefits from ecosystem services as well as altering ecosystems (Kittinger *et al*., 2012). These proximate relationships are partly the effect of distal drivers that indirectly impact on the relationship between ecological and social systems. The distal drivers, individually or collectively, can escalate the magnitude of a proximate driver resulting in significant ecological changes (Brewer *et al.,* 2012). Here I explore the interactions between proximate and distal drivers and their individual contribution to the extraction of reef resources and identify the main drivers of reef resource use in Fiji and Solomon Islands. Coastal households and communities are actively involved in fishing but their motives for fishing differ (Young *et al.,* 2016). In this study, distal drivers are referred to factors that indirectly affect reef resources and proximate drivers are factors that directly affect reef resources. I used household interviews, key informants interviews and focus group discussions to elucidate the drivers of resource use in Fiji and Solomon Islands.

4.2 Results

4.2.1 Proximate and distal drivers of reef resource use

The drivers of marine resource use in Fiji and Solomon Islands were grouped to show whether the drivers for reef resource use were proximate or distal. Majority of the identified drivers of reef resource use were distal and the only proximate driver was access to new fishing gear and fishing methods. The underlying drivers of fishing in Fiji and Solomon Islands were: 1) need for food and income; 2) increase in population; 3) markets; 4) cultural and religious obligations, and 5) way of life. These distal drivers were further classified as originating from within and/or outside the community. Drivers within the community are those that influence reef resource use within the boundary of the community. Drivers outside the community are those that influence reef resource use outside the boundary of the community

Table 4.1: Drivers of reef resource use categorized within the community and/or outside the community

Drivers of reef resource use	Proximate	Distal	Within the community	Outside the community
Requirement for Food and income		✓	✓	
Access to new fishing gear and fishing methods	✓		✓	
Increase in population		✓	✓	✓
Markets		✓	✓	✓
Cultural and religious obligations		✓	✓	✓
Way of life		✓	✓	✓

4.2.2 Food and income

Results from household interviews revealed that more than 50% of the households of communities surveyed in the Solomon Islands fish for food; however some households are still subsistence fishers, fishing for food only. In Fiji, households from Daku, Ligau and Yaro fish for food and income. Households from the other communities in Fiji such as Nakodu, Tuatua and Waiqanake fish mainly for food, with only a minority of community members fishing for food and income (Fig. 4.1).

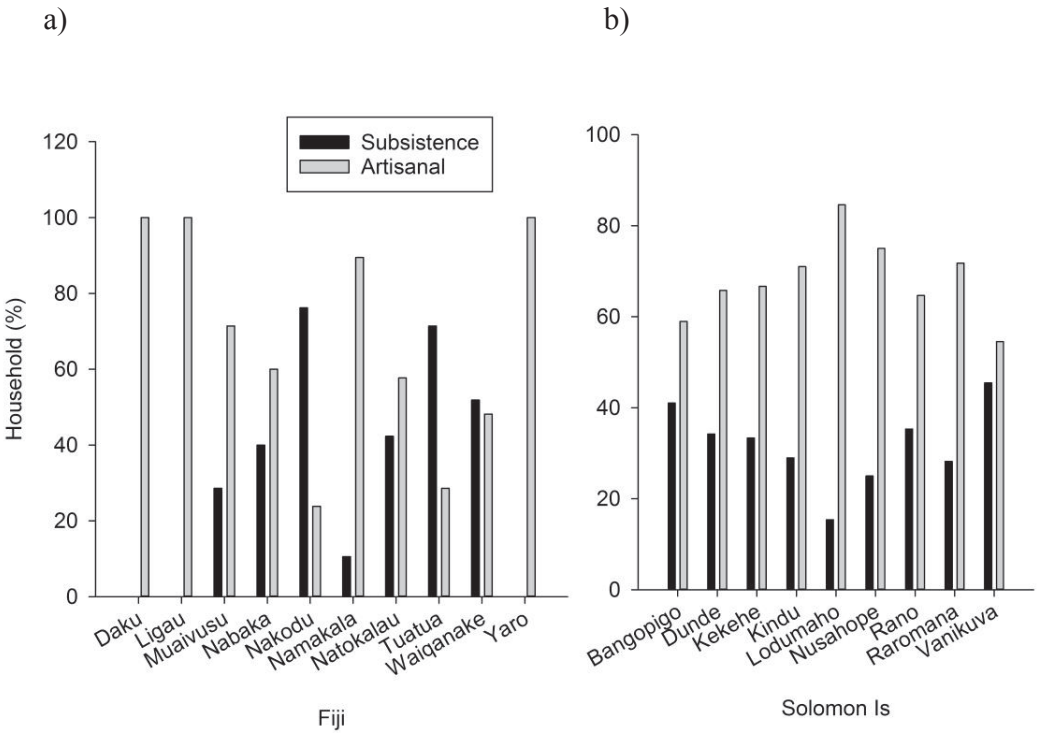

Figure 4.1: Percentage of households fishing for food only and households fishing for food (subsistence) and income (artisanal) in (a) Fiji and (b) Solomon Islands.

The top five fish families that are targeted by fishermen in Solomon and Fiji based on the household interviews are shown in the table below (Table 4.2) Respondents were asked to state 5 fish species that they target for consumption and for sale. The three targeted fish families that were common to both countries were Serranidae (grouper), Lethrinidae (emperor) and Lutjanidae (snapper). The other two fish families most frequently targeted in Fiji were Acanthuridae and Scarinae while in the Solomon Islands they were Carangidae and Scombridae.

Table 4.2: The top five fish families targeted by fishermen in Fiji and Solomon Islands based on the fish species they target for consumption and for sale.

Rank	Fiji	Solomon Islands
1	Serranidae	Lethrinidae
2	Lethrinidae	Lutjanidae
3	Acanthuridae	Scombridae
4	Lutjanidae	Serranidae
5	Scarinae	Carangidae

Interviewees described how fishing practices have changed. Fishing in the past was mainly for household consumption in Fiji and Solomon Islands. An interview respondent from Solomon Islands said:

"In the 1950s and 1960s we fished mainly for household consumption." (J.K, Dunde, Solomon Islands, 02/03/2015)

Similar responses were obtained from focus groups and key informants interviewees in Fiji who stated that fishing in the past was mainly for food. In both countries, most fishers fish on Saturdays for Sunday lunch and dinner. In the past fishing was selective: specific species were targeted and only big fish were caught.

"When I went fishing in the 70s, I only fished for a particular fish that I wanted to eat and I would target that particular fish only, but now people just catch whatever they can catch, small or big" (W.W, Tuatua, Fiji, 12/11/2014). This shows that there were more fish available to fishers to choose from in the past and fishing was mainly for food. Another respondent from Fiji said that "I fish mainly for my family first and the rest is sold. It does not matter if I do not have any fish to sell as long as I have fish for my family to eat" (K.D, Muaivusu, Fiji, 02/12/2014). For this respondent, feeding the family was still the main reasons for fishing but, as discussed below, this now holds true only for some communities.

For households in the communities of Daku, Ligau and Yaro on Kia island in Fiji, where there is limited land to grow crops, fishing is their main source of livelihood. Respondents during the focus groups interviews on Kia Island reported that all families are engaged in fishing activities for the purpose of selling the fish for money. Women from Kia Island did not fish in the past but said that the need for money had forced them to start fishing to provide their families with a decent income. In Solomon Islands the need for money was driving people to fish more, respondents said, and this placed pressure on people to adopt new fishing methods in order to obtain a good catch. FGDs in Fiji and Solomon Islands revealed that most fishermen and women sell large fish they catch where markets are available and take home the smaller fish for consumption.

"Fishing is my main source of income; therefore I fish mainly to sell. With increase in cost of living and expenses to be paid, I would rather sell the fresh fish that I catch and buy canned tuna from the shop" (G.H, Dunde, Solomon Islands, 27/02/2014).

Focus group discussions with communities on Kia Island revealed that fishing during the early 80s was done communally; a single fishing boat was used by all the villages to catch fish. A committee was set up to coordinate and manage the operations of the boat. The boat enabled the communities to fish on the outer reefs of Kia and fish caught were sold at the nearby market on the neighbouring big island Vanua Levu. Villages were promised by the committee that money collected would be used for community development. According to the FGD respondents, this worked well until the early 1990s, when according to the FGD respondents the committee started

to abuse the funds and this prompted families to purchase their own boats and sell their catches individually. Community members reported that only when they fished individually were they able to build their houses and use the income earned from fishing to contribute to community development.

As fishing became a major source of income for coastal communities in Fiji and Solomon Islands, there was a shift from the consumption of fresh fish to an increasing consumption of canned fish, canned meat, noodles, bread, biscuits and many others imported products that are purchased from local shops.

"My children don't want to eat sweet potato, taro or cassava for breakfast but would prefer bun, pancakes, and biscuit. For lunch they would rather have noodles with canned tuna or meat instead of root crops with fresh vegetables. In the evening if vegetables are cooked, there has to be some fish or meat with it for my children to eat them" (H.P, Kekehe, Solomon Islands, 05/03/2015).

4.2.3 Fishing gear and method

According to KIIs and FGDs in Fiji and Solomon Islands, fishing gear has changed over the years. There has been a shift from the use of traditional fishing methods and gear to the use of modern fishing gear introduced by foreigners (Peace Corps volunteers, government representatives) that visited these communities (Table 4.3). The introduction of spear guns, masks and torches by the Peace Corps increased catches and encouraged fishermen to change fishing gears and methods.

"I was the first person to use a spear gun in the village of Tuatua in 1976 and this was brought by a Peace Corps volunteer who came and worked at the government station in Nasau" (K.T, Tuatua, Fiji, 12/11/2014).

A key informant from Raromana in the Solomon Islands clearly remembered the names of the two Europeans, who were also Peace Corps volunteers, who first introduced spear guns into the community in the early 1980s. It is clear from the interviews that modern fishing gears or 'white man's gear', gained prominence in the communities after Fiji and Solomon Islands gained independence, in 1970 and 1978 respectively.

One of the traditional fishing method that was used in both countries is called "*kuwarau*" in Solomon Islands and "*yavirau*" in Fiji. This is a fish drive using traditional vines and coconut leaves to round up the fish, in which large numbers of people are involved (Figure a). A gillnet, poison leaves and/or hand spear are used to collect the fish when the fish drive is completed. *Kuwarau* or *yavirau* was mostly used on special occasions (e.g. village feasts, marriages, deaths), when a large quantity of fish was needed for food. Nakodu (Fiji) was the only community surveyed still practicing this traditional fishing method. *Yavirau* is destructive because

practically all species and sizes of fish are caught and because of the impact of numerous people on the reefs stomping on coral heads.

Figure 4.2: Fish caught after a traditional fish drive in the community of Nakodu, Fiji, 2013.

Source : WCS Fiji, 2013

The use of poison (leaves and vines) is still practiced in the Solomon Islands, but no longer in any of the studied communities in Fiji. Another traditional fishing method, used only in the Solomon Islands, was bamboo fishing. A fishing line made from a special vine was tied onto a bamboo pole with traditional hooks made from shells and used mainly to fish for bonito (skipjack tuna) and coral reef fish. This method was no longer used after the 80s.

The communities of Muaivusu, Waiqanake, Nabaka and Namakala in Fiji still fish using traditional fish traps. The fish traps are made from reeds and vines and are often prepared in October and placed at sea near mangrove areas in November. It is checked at every low tide for fish and remains in place for at least six months. Different species and sizes of fish are caught using this method. For households that are able to construct fish traps, they provide an additional source of fish for consumption and sale during the Christmas season.

According to the respondents, spear gun, Hawaiian sling and fishing line are the top three fishing gears used in Fiji while fishing line, spear gun and nets are most commonly used in the Solomon Islands. Table 4.3 shows how fishing gear has changed over the years.

Table 4.3: The general change in fishing gear used by the study communities studied in Fiji and Solomon Islands. All the information in this table was obtained from KIIs and FGDs. Fishing gear which disappeared is indicated in red and new fishing gear which appeared over the years is given in blue.

Country	1960s	1970s	1980s	1990s	2000
Fiji	Fishing line Hand spear Hawaiian Sling Fishing nets *Yavirau* (traditional fish drive) Duva (fish poison)	Fishing line Hand spear Hawaiian Sling Fishing nets *Yavirau* (traditional fish drive) Duva (fish poison) Spear gun (dive only during the day)	Fishing line Hand spear Hawaiian Sling Fishing nets *Yavirau*) Duva (fish poison) Spear gun and underwater torch (dive during the day and night)	Fishing line Hand spear Hawaiian Sling Fishing nets Duva (fish poison) Spear gun and underwater torch (dive during the day and night) *Yavirau* Fish trap	Spear gun and underwater torch (dive during the day and night) Fishing line Hawaiian Sling Fishing nets Fish trap
Solomon Islands	Fishing nets Fishing line Fishing ropes and *ghaili* hooks (made from shells) Bamboo fishing Hand spear Traditional fishing nets for catching tuna Kuwarau Poison leaves	Fishing Nets Bamboo fishing Kuwarau Poison leaves Fishing line Fishing net	Fishing line Fishing nets Spear gun and torch (dive during the day and night) Hawaiian sling Bamboo fishing Poison leaves Kuwarau	Fishing line Fishing nets Spear gun and torch (dive during the day and night) Hawaiian sling Poison leaves	Fishing line Fishing nets Spear gun and torch (dive during the day and night) Hawaiian sling Poison leaves

It is evident that the modern fishing gears have replaced the traditional methods of fishing. Based on FGDs and KIs, the basic reason for this change was that modern methods enabled people to catch more fish in a shorter time with less effort. A respondent from Fiji mentioned that when spear guns were first introduced, catching fish was effortless. Just one or two divers were able to catch all the fish needed for a village feast, instead of the traditional *yavirau* which required many more people. Night diving was practised in both countries. However this was a major concern in most communities in Fiji, with respondents from focus groups stating that it was one

of the main reasons for the decrease in reef resources. Household surveys revealed that only 31% and 10% of fishing households owned spear guns in Fiji and Solomon Islands respectively. Handline was the most used fishing gear, with more than 70% of fishing households owning fishing lines in both Fiji and Solomon Islands.

The purchase of fibreglass boats has allowed fishermen to fish on outer reefs anytime during the day and night. In the community of Yaro (Fiji) alone, the researcher counted nineteen fibre glass boats with engines, which is a high number for a small isolated village with just 24 households. In Solomon Islands most households use canoes to paddle out to reefs to fish. Respondents said the use of 'white man's gear' instead of traditional gear does not guarantee a big catch anymore today; therefore fishermen from both countries have developed additional skills and knowledge in order to catch more fish using spear guns during the day.

"Even with my spear gun, I still find it hard to catch fish during the day because the fish have become smarter than us. When they see us coming, they swim away really fast. You have to be patient and have a lot of air in your lungs to be able to stay underwater for a while or even go down deeper to be able to shoot a fish" (W.W, Tuatua, Fiji, 12/11/2014).

4.2.4 Markets

It was apparent from the interviews and FGDs that the proximity of markets where fish could be sold has a substantial impact on the way people fish. Household survey results from Fiji and Solomon Islands mentioned fishing as the households' main or second source of income. In Fiji, a majority of the household respondents from Daku, Ligau and Yaro in Fiji stated that they totally dependent on fishing as their main source of livelihood and income. The closest market is approximately 40km away by boat, but respondents stated that the presence of a middleman on the island had encouraged the three communities on the island to fish more. The middleman was a part of a Chinese-owned company which bought not only fish but all marine products, including invertebrates. Fish bought by the middleman were sent to the company's shop in Labasa town and from there to the capital of Fiji, Suva, where fish were sold at a higher price. The middleman made at least one trip to Labasa each week after purchasing at least $2000FJD worth of fish from fishermen in Kia. Prices of fish bought by the middleman from fishermen are calculated per kilogram (Table 4.4). Unlike in the Solomon Islands, fish sold in Fiji are graded according to species and the price per kilogram for each grade differs (Table 4.4). "I fish every day because I can sell my catch to the middleman who is in Yaro village. When I catch more fish, I will have more money. If there was no middleman in the village we would have to take our catch to the market in Labasa to sell it, and the market only takes place on Friday and Saturday. Now I can earn money almost every day" (A.R, Yaro, Fiji, 12/09/2014).

We were informed that the middleman owned five fiberglass boats with engines which were kept on the island and used by the fishermen on the understanding that the costs of fuel and boat hire would be deducted from the price paid for their fish. For this reason fishermen in Kia fish in groups so that these costs can be shared amongst the fishers. Focus group discussions with men

and women in Kia revealed that fishers sold A, B and C grade fish to the middleman and consumed the rest. It has the potential change the dynamics of the coral reef ecosystem due to the targeted removal of fish species at different functional levels.

In the villages of Tuatua, Nakodu and Natokalau in Fiji, there are a few fishermen who dive at night. Fish caught by night divers are sold in bundles. Fish sold in bundles are not graded, so the fishermen decide on which fish species to include in each bundle and sets the price. The number of fish in a bundle depends on the size of the fish. Night divers reported that they cannot meet the high demand from the community [fishing by day alone]. Fishing at night allows them to catch more fish, targeting big fishes only (>50cm in length). The markets where fish are sold, and the respective prices, are listed below (Table 4.5). Thus high demand from local consumers has forced fishermen to fish more at night, placing increased pressure on reef resources.

The communities of Muaivusu, Nabaka, Waiqanake and Namakala in Fiji, in addition to selling fish, also sold sea urchin (*Tripneustes gratilla*) in the market at Suva. Focus group discussions with women from these communities revealed that the collection of sea urchins was done by both men and women but the removal of gonads and marketing was done by the women. The Chinese community in Suva placed orders with individual households and would buy a two litre container full of sea urchin gonads at $40-$45FJD. When sold at the Suva market, the same two litre container might fetch only $25-$30FJD. Respondents from FGDs indicated that they prefer to get orders from the Chinese community because of the higher price and the fact that the urchins are sold in the village thus reducing travelling expenses. Although access to markets is crucial to households, this example from Fiji shows the important role buyers have on the price of sea urchins. The higher price offered by the Chinese benefits households but is likely to increase pressure on populations of sea urchins.

Table 4.4: The price paid by the middleman in Kia for different fish families.

Grade	Fish Family	Price/kg (FJD)
A	Serranidae, Lethrinidae, Siganidae, Scombridae	$6.50
B	Lutjanidae, Haemulidae, Mugilidae	$5.50
C	Acanthuridae, Scarinae, Mullidae	$4.00
D	All other families	$2.50

Table 4.5: The price of fish at markets where fish is sold by communities in Fiji.

Community	Market	Price of Fish ($FJD)
Kia	Middleman in Yaro, Labasa town	Fish sold in kilograms $20 - $25 a bundle
Navakavu	Suva market	$20 a bundle
Natokalau	Levuka town, within village	$20 a bundle
Nakodu	Within village	$10-$15 a bundle
Tuatua	Within village, Nasau government station	$10-$15 a bundle

Communities in Munda town (Dunde, Kekehe, Lodumaho, Kindu) in the Solomon Islands started selling fish when people from other communities migrated to Munda and began to buy fish from the local fishermen in the 1980s according to focus group discussions. Today fishermen in Munda sell their catch to the middlemen who are present in the villages and also at the main town centre. Fish are sold, priced in kilograms, to the middlemen and are not graded as in Fiji. All species of fish are sold to the middlemen at a price of $15SBD per kilogram (Table 4.6). The middlemen are locally based, unlike in Fiji where the middleman works for a Chinese-owned company. Fish bought by the middlemen are sold at $22-$25SBD/kg to customers in town. Some middlemen send their fish to Honiara town, where the fish is sold at a higher price. Fish are also sold individually (not in kilograms or bundles) within the villages, where they do not fetch more than $15SBD as a higher price would be too expensive for the villagers. Interestingly all studied communities in Solomon Islands also sell cooked fish, which is baked in hot stones and served with pudding (made from grated cassava) at the markets in Munda and Gizo towns, to logging companies and schools and during community fundraising events. Cooked fish is sold for a price equivalent to $5 - $10SBD a parcel.

Respondents in FGDs in Vanikuva, Bangopigo, Rano, Raromana and Nusa Hope in Solomon Islands reported that fishing was one of their main sources of livelihood, but transportation of catch to markets in Munda and Gizo remained a problem. Fishermen did not have access to a proper ice facility where ice could be purchased for storage of catch. The high cost of fuel and lack of boats prevented the communities from sending their catch to the market. Apart from fish, fishers in Nusa Hope and Kindu also collected bivalves called *deo* which are collected from mangrove swamps by men and women and sold at the market in Munda at $10SBD a heap. One heap of *deo* contains 30-40 shells.

Fishermen from Fiji and Solomon Islands harvest invertebrates, especially sea cucumbers. Every fisherman, while fishing for fish, also collects sea cucumbers if he encounters them. Sea cucumbers are not a delicacy in the region (apart from *Holothuria scabra*, which is consumed in Fiji), but they are a high-value commodity in the Asian market. In communities of Muaivusu, Namakala, Nabaka, Waiqanake, Ligau, Daku and Yaro in Fiji, sea cucumbers are sold raw in most instances while in Koro and Ovalau they are dried and transported to Suva to be sold.

Fishermen in Solomon Islands reported they sold sea cucumbers to the middlemen either raw or dried.

Table 4.6: The price of fish at markets where fish is sold by the study communities in Solomon Islands.

Community	Market	Price of Fish ($SBD)
Munda	Middleman Munda market Hospital market	$15/kg $5-$10 per fish (baked) $5-$10 per fish (baked)
Lokuru	Within community Logging company Munda market Middlemen in Munda	$10-$15 per fish $15-$20 per fish $5-$10 per fish (baked) $15/kg
Raromana	Munda Gizo Noro Markets in Munda, Gizo, Noro and Rigi Within village	$15/kg $15/kg $15/kg $5-$10 per fish (baked) $5-$15 per fish
Nusa Hope	Munda Within the village School	$15/kg $5-$10 per fish $5-$10 per fish

Participants in focus group discussions and KIs in Fiji and Solomon Islands clearly stated that the availability of markets and the need for income have encouraged people to sell the big fish they catch and take the small fish home for consumption.

4.2.5 Increase in population

The increase in population in all communities was identified by household interview respondents, key informants and focus groups as one of the main drivers of increased fishing pressure in both Fiji and the Solomon Islands. Communities in both countries have experienced an increase in the number of households and inhabitants over the years and it is expected that populations will continue to increase over the next ten years. The increase in population has placed a lot of pressure on marine resources, with fishermen competing for the same resource in a limited space.

"Our population has increased a lot and there are more fishermen now than before" (D.K, Dunde, Solomon, 03/03/2015).

"In the 1970s the community of Vanikuva had only four houses and Bagopingo had about ten. But now you can see that there are almost forty houses in Vanikuva and more than one hundred

houses in Bangopingo. There are houses in these two communities where five families are staying in one house" (M.T, Vanikuva, Solomon, 16/04/2015).

"There are more babies being born every year. Men and women from other provinces have come to Munda to find work and most got married and settled here. I fish every day and it does not matter whether I catch a big fish or a small fish as long as I have something to eat with my potato" (J.S, Kindu, Solomon, 12/03/2015).

"This village had less than twenty houses in the 70s but the number has more than tripled now and we have a small *iqoliqoli* to fish from" (E.T, Natokalau, Fiji, 24/09/2015).

According to respondents from Solomon Islands, the increase in population there is likely driven both by more children being born and/or through migration for work and marriage. Migration of people into communities as observed in Solomon Islands will result in more heterogeneous communities, which might affect the collective governance of reef resources. An increase in population in Fijian communities is probably mainly due to more children being born, as communities there are more homogeneous, compared to those in Solomon Islands.

The impression the researcher had after discussions with respondents during HHS, KIs and focus groups in all communities was that increase in population had increased the number of fishers. All respondents in FGDs, KII and household surveys from both countries mentioned that there were more households and houses now compared to four decades ago. Fish being the main source of protein for these coastal communities, an increase in population is likely to drive people to fish more which would have a significant impact on the reef resources. An increase in population will increase the competition and demand for scarce resources. It can also change resource use patterns which could lead to loss of biodiversity of species. For example in the Dunde in Solomon Islands, people are fishing day and night. Interviewees and informal discussions in both countries identified increasing population as one of the causes of declining reef resources in the communities. This might not be the case for all communities as people have migrated to communities for employment into different sectors. The study was limited in analysing a direct relationship between increasing population and fishing effort.

4.2.6 Cultural and religious obligations

Household surveys showed that 94% of households in the Fiji study communities participated in community events in the last twelve months compared to only 70% from the Solomon Islands. Moreover the average number of events that households in Fiji engaged in over the past year was 15, compared to 3 in the Solomon Islands. It was evident from FGDs in Fiji that communities engage in numerous family, village and church activities every year.

Household income was primarily used to buy food and pay for household needs. Besides food, respondents from Fiji listed church levies and village charges as their second and third most

important expenditures, while for Solomon Islands it was education and the church respectively. A chi-squared test on expenditure in Solomon Islands and Fiji was done to determine whether there were significant differences in the kind of things households spend money on between Fiji and Solomon Islands. There were significant differences for food (x^2=37.931, df=3, p<0.001), church levies (x^2=32.159, df=3, p<0.001) and education (x^2=24.653, df=3, p<0.001) and no significant difference in household bills and village charges.

More than 90% of households from communities surveyed in Fiji were members of the Methodist church (Table 3.4). The Methodist church headquarters in Suva requires each member to pay an annual levy. The communities also pay the salaries of church pastors and church stewards who are serving in their local church. Village charges cover the costs of a levy paid to the provincial offices annually per community member, as well as funding local village commitments such as school fundraising, marriages etc. Communities such as Ligau, Daku and Yaro in Fiji that depend only on marine resources for income spend relatively more time and effort fishing to meet these demands.

"The number of events that I have to attend and contribute to in the village is so many that I cannot even save enough money to repair my house." (N.V, Tutatua, Fiji, 30/10/2014)

"When a family is asked to contribute to any village or church event, we have to do it and it is not an option. Otherwise you can be discriminated against in the village, because it is a small community and everyone knows who did not contribute" (A.R, Yaro, Fiji, 12/09/2014).

It is evident from these statements that external social obligations are met by households at the expense of meeting family obligations. For example, savings for household items can be given if there is a monetary request from the elders of the community. The status of a family in the community is more important than the needs of the family.

According to participants in focus group discussions and key informants in Fiji, communities place too many demands on their members compared to Solomon Islands. In informal discussions, some people commented that life in the village was difficult. Because people live communally they feel obliged to participate in every community event or occasion and to contribute either monetarily or in kind.

4.2.7 Way of life

Fishing in both countries is a lifestyle. In the communities surveyed in Solomon Islands, almost everyone in the village went fishing or was engaged in fishing. It was observed in Solomon Islands when not engaged in other activities, in their free time most people would paddle their canoes and catch fish. Fishing was like a game in Bangopigo and Rano, where men would compete to catch the biggest and most fish. A successful fisherman would gain respect from peers, and women would be attracted to him if he was not married. Fishermen who landed big

catches stated they had to hide their fishing gear and keep their technique secret from other fishermen. They said there were jealous people in the village that would want to steal their fishing gear because of their good catch.

While only some households fished in Koro and Natokalau, these communities were the exception. The study revealed that all households in Ligau, Daku and Yaro and most households in Muaivusu, Nabaka, Waiqanake and Namakala engaged in fishing. Traditionally in most communities in Fiji, fishing was done by traditional fishermen (a clan in a community that specialises in fishing) and the fish caught was often shared amongst the households or used for a feast. This tradition has evolved over the years with fishing becoming a household or individual activity. Similar to fishermen in Vanikuva and Bangopigo in Solomon Islands, fishermen from Daku, Ligau and Yaro in Fiji would often compete to catch the biggest and the most fish.

4.2.8 Discussion

Understanding what drives coastal communities to fish is important in order to address the declining reef resources and low catches currently faced by fishermen. In this respect, there were similarities and differences among households and communities. The need for food and income was the principal distal driver of reef resource use in coastal communities in Fiji and Solomon Islands. Communities in Fiji and Solomon Islands identified the importance of reef resources, especially fish, as a source of food and income. The need for food and income has a significant impact on the availability of reef resources. Fishing in the Pacific region in the past was mainly for food (Johannes, 1981; Gillett, 2009; Bell *et al.,* 2015; Young *et al.,* 2016) but now is a major source of income for most coastal communities (Bell *et al.,* 2009). There is an inadequate range of crops and animal protein in the Pacific (FAO & WHO, 2001), so consumption of fresh fish and other marine resources is very widespread. Given the degree of dependency on reef resources and the amount of fish consumed in the region, it is unsurprising that these resources have been intensely exploited by coastal communities (Kronen *et al.,* 2012).

The average intake of fresh fish consumption per person in the Solomon Islands is greater than in Fiji however coastal communities in both Fiji and Solomon Islands rely on fresh fish consumption for a large percentage of protein intake amounting to 92% and 97% respectively (Bell, 2009). In Roviana Lagoon, Solomon Islands, individuals and households exploit and harvest natural resources for subsistence and for cash to access goods and services that people perceive would improve their well-being (Aswani, 2002). This is also the case in Fiji where individuals and households fish as a means of subsistence and as a source of income (Jupiter *et al.,* 2012; Mathews *et al.,* 1998; Veitayaki, 1997). A decline in consumption of fresh fish observed in the province of Lau in Fiji was mainly attributed to the availability of alternative sources of income (Turner *et al.,* 2007). The availability of alternative sources of income and access to markets has influenced a change in the consumption patterns of households. A study by Valmonte-Santos *et al*. (2016) in Fiji, Solomon Islands, Vanuatu and Timor-Leste found that

there was an increasing consumption of cheaper food imports, such as canned fish and meat, white bread, soft drinks and many other products, instead of the local foods, i.e. fresh fish, local root crops and vegetables. The change in diet could lead to obesity and related health problems (Parry, 2010) and may prove unsustainable given the escalating prices of imported foods in these countries (Johnson & Onwuegbuzie, 2004). Globally a change in people's diet has been driven by rising per capita income and globalization of food systems, with an overall trend towards less consumption of starchy staple foods (rice, wheat and potatoes) and more of fat, meat, canned fish, and processed foods (Nelson *et al.,* 2005). It was observed and FGDs reported that there was high consumption of foods such as noodles, canned tuna and beef, biscuits etc. among households in Fiji and Solomon Islands. The purchase of imported and processed foods can be expected to have significant impact on the availability of reef resources where reef resources are the communities main or only source of income. The need for money and food thus affects the relative abundance of reef resources both directly and indirectly.

In Fiji, communities mentioned church and village obligations while communities in Solomon Islands stated education and church respectively as their second and third largest categories of expenditure. A study in Makira, Solomon Islands, reported that income from fishing enables people to buy imported food and pay for school fees (Fazey *et al.,* 2011), which was consistent with the results of this study. Church fundraising in the Solomon Islands was primarily for the local church. This was not the case in Fiji, where the church, acting as a distal driver (within and outside the community), was one of the main reasons for the commercial harvesting of reef resources. Jupiter *et al*. (2012) reported the opening of a *tabu* area in Kia by communities for the purpose of raising funds to support the school, church and provincial taxes paid by the residents. Education in Fiji at the primary and secondary level is free, so parents do not pay school fees or have to buy text books. While income generation has many benefits (such as access to health, education and ability to buy imported food), money in communities can have undesirable outcomes including loss of social cohesion, land disputes and increasing resource use (Fazey *et al.*, 2011). For example, in Fiji and Solomon Islands, excess catches were often shared between family members in the past but, today, excess catches are sold to family members.

The increased accessibility of markets is one of the main drivers of the high exploitation of reef resources within coastal communities in Fiji and Solomon Islands (Kronen *et al.,* 2010; Brewer *et al.,* 2012; Jupiter *et al.,* 2012; Brewer, 2013). The presence of fish markets in coastal communities has made it easier for community members to sell their catch. The presence of markets (via the presence of middleman) on Kia Island and Munda and easy access to the market at Suva for the communities of Muaivusu, Nabaka, Waiqanake and Namakala has enabled members of these communities to sell their catch daily. Brewer *et al*. (2009) found that in the Solomon Islands distance from markets was positively correlated with increased reef fish abundance. Cinner *et al.* (2016) recently reported that market gravity is the single most important driver of declining reef fish biomass worldwide. They postulated that fish biomass decreased as the size and accessibility of markets increased. A recent study on Kubulau district in Fiji reported

that 75% of fishers sell their catch directly to middlemen (Dacks *et al.*, 2018). Improvements in storage and transportation by middlemen and a higher market value of marine resources (Kronen *et al.,* 2006) have increased harvesting and placed a lot of pressure on coral reef fisheries (Brewer *et al.,* 2009). Cinner & McClanahan (2006) reported from Papua New Guinea that the proximity of markets drives communities to fish and that markets typically sell bigger fish of species preferred by consumers. This is not only a local phenomenon; the development of global markets for reef fish products also has significant impact as a driver of harvesting of reef resources (Berkes *et al., 2006;* Ferse *et al.,* 2012; Purcell *et al.,* 2013).

In the communities of Daku, Ligau and Yaro on Kia Island in Fiji, the middleman that buys fish is linked to a well-established company that exports fish and other marine products and has its main offices in Labasa town and Suva city. The middleman has monopolized the trade in fish to the point that fishermen in Kia complained about the inconsistencies in the prices of fish, over which they felt they had no control. The middleman on Kia Island provides boats and fuel to fishers on the island under the license granted to him by the Department of Fisheries. When fishermen return from fishing, deductions are made from their income to cover the costs of boat hire and fuel. Therefore, in order to get a decent income for the day, fishermen on Kia fish in groups and catch as much fish as they can to cover their expenses. This is similar to the patron–client system that is practiced in Indonesia, but on a very small scale (Pelras, 2000; Ferrol-Schulte *et al.,* 2014).

When the market price of fish increases, one can expect an increase in the intensity of fishing (Cleasby *et al.*, 2014). The increase in market price for reef products could stem from a scarcity in reef resources but this was not measured in this study. More importantly, FGDs reported that the increase in fish prices was linked to the increasing cost of living in both countries. Access to markets is important for the livelihoods of coastal communities but can also have negative effects. Cinner (2005) found that customary sea tenure systems in Papua New Guinea weaken with proximity to provincial markets. Easy access to markets has been a contributing factor to the declining success of some local marine managed areas in Fiji where fishermen would fish in *tabu* areas to get a decent income (Rohe *et al.,* 2017).

There seems little doubt that population growth has led to increasing extraction of reef resources in both countries. Many participants in FGDs and KIIs stated that there are more houses and more people in the villages now compared to four decades ago. Respondents from both countries also said that there were more fishermen on the reef than in the past. Similarly, the increase in population along the Kenyan coast is the main driver of a massive increase in pressure on the coral reefs there from different fishing activities (Mangi *et al.,* 2007). Many other studies report that the biomass of reef fish is impacted by direct human use, which causes shifts in fish species composition, abundance and habitat structure (Dulvy *et al.,* 2004; Jennings & Polunin, 1996;1997; McClanahan, 1997; McClanahan & Mangi, 2004; Newton *et al.*, 2007). Thus the perceived increase in population reported by respondents in Fiji and Solomon Islands could potentially exacerbate overexploitation and overfishing of reef resources. The increase in

population in Fiji and Solomon Islands is related to an increase in births in communities and also migration of people into communities. The search for employment has led to the concentration and expansion of urban centres (Aswani & Sabetian, 2010; Dalzell *et al.,* 1996), which has been linked to the decline of local fisheries (Cinner & McClanahan, 2006; Gillett & Moy, 2006). In Solomon Islands, people have migrated into Munda from other, smaller communities in search of employment and better opportunities. People also move among communities in both Solomon Islands and Fiji as a result of marriage especially through women bringing their husbands to live in their communities. Limited accesses to jobs and land for these migrants have forced them into fishing as a source of livelihood. A study in Kiritimati Islands showed that an increase in population over a ten year period from 1997 (due to deliberate relocation) caused a decline in fish assemblages due to increased fishing pressure (Fenner, 2014). In a study of 39 islands and reefs in the US Pacific, Williams *et al*. (2011) documented that large fish were more abundant on remote islands and reefs with low human populations than on populated islands and reefs. Increase in population observed in all communities in Fiji was more likely to affect the number of people that are engaged in fishing. For example in the communities of Muaivusu, Namakala and Waiqanake in Fiji, the number of households have increased over the years and at least one member of the household is engaged in fishing. In Fiji and Solomon Islands communities, access to fishing grounds is not restricted to any person as long as they are staying in the community which includes migrants. The need to monitor and restrict access to reef resources using CMT and new management rules is crucial for the sustainability of reef resources as population increases.

Education levels in both countries are low, with more than 90% of respondents having only primary and secondary education. Low education levels could make it difficult for people from communities to compete for employment in urban centres (Mangi *et al.,* 2007). In situations where people are able to find employment, wages are often not sufficient to meet household needs. This was evident in the communities of Muaivusu, Waiqanake and Namakala in Fiji, where households continued to fish for income even though a member of the household was working in Suva.

Although increasing population can affect the condition of reef resources, Cinner & McClanahan (2006) suggest that markets may be more important in determining the condition of a fishery than human population density; thus controls on markets at the regional and global level may contribute more to achieving sustainable resource use than efforts to control the size of the local human population. However the results of this study suggest that in communities without access to markets, population increase is likely to play a major causative role in overharvesting of reef resources.

The desire to catch more fish with less effort has prompted communities to change from traditional fishing gear to introduced ‘white man’s gear’. The shift from the traditional *yavirau* and bamboo fishing to the use of handlines, gill nets, Hawaiian sling and spear gun by households has enabled people working alone to fish efficiently. The introduction of spear guns,

dive masks and torches has allowed the fishermen to fish day and night. Most of the spear guns observed in Solomon Islands were homemade, while in Fiji spear guns were purchased from shops. Hawaiian slings were locally made in both countries, using a rubber band and a sharpened iron rod. The advanced technology in fishing has enabled fishers to target coral reef fishes in their hiding places, using gear such as night lights, scuba, global positioning system (GPS) equipment and monofilament lines (Birkeland, 2004). GPS and other new technological advances could reach the coastal communities as the demand for reef resources increases. Gillett & Moy (2006) reported that spearfishing produces 50-80% of inshore fisheries catches in Fiji and Solomon Islands, with the most targeted fish being parrotfish, goatfish and surgeonfish, and this is consistent with the results of this study. Night spearfishing is common in most communities in Fiji and Solomon Islands as a strategy used by communities to increase catches (Hamilton *et al*., 2012; Jupiter *et al.,* 2012).

Respondents in FGDs and KIIs in Fiji and Solomon Islands stated that night diving was one of the main causes of the decrease in reef resources. This contrasts with the results of HHS, which found that households mainly use fishing lines and gill nets for fishing. This difference in results could be related to community members observing high abundance and biomass of fish caught by night divers. Most people in Fiji and Solomon use handline because it is accessible and easy to use while night diving require more skills and technique. Although most households use fishing lines and nets, more destructive gear such as spearguns could still have the greatest impacts when these are used. A study conducted by Januchowski-Hartley *et al*. (2011) on fish flight initiation distance (FID) showed that fish families that are targeted primarily by spear guns have higher FIDs. The study also reported that Acanthuridae and Scarinae display a higher proportion of wary behaviour, swimming away or displaying immediate flight in the presence of a fisher. This is consistent with statements by respondents in this study that fish are smarter nowadays and that they flee when spear fishers are present in the water.

The participation of youths in fishing was observed to be prevalent in Fiji and Solomon Islands. Of interest was the exhibition of male bonding and camaraderie, which was evident from the interviews and observations in the two countries. Similar results were obtained in a recent study conducted in Solomon Islands and Australia (Young *et al.,* 2016). It is known that the show of masculinity through aggressive behaviour is an attempt to establish a fisher's position in society and gain respect and admiration from his peers (Arnett, 1992; Young *et al.,* 2016). Fabinyi (2007) observed that young fishermen would often speak of their fishing experiences in terms of personal strength, bravery, pride and skills. This was evident in both countries studied; young men would share their fishing experiences over a kava bowl in Fiji or while chewing betel nut in Solomon Islands. Catching the biggest fish during fishing trips was the aim of every young fisherman, in the expectation that this would attract women. Young (2016) considered that the high-risk, high-gain attitude shown by young fishermen demonstrated their financial capacity to potential partners. In this study this was found to be the case in the communities of Vanikuva and Bangopigo in the Solomon Islands, where young fishers with huge fish catches attracted women.

The desire for financial gain by young fishermen could result in less value being placed on traditional management systems and the views of local chiefs and elders, as the sea is increasingly viewed through a commercial lens (Veitayaki, 1997). Young male divers in Natokalau reported that they were not part of the establishment of a *tabu* area in their community. This was used to justify egocentric behaviour, whereby they used their constitutional fishing rights to fish in the closed area because the area had (for them) no legally binding status (Rohe *et al.,* 2017).

4.3 Conclusion

As in many societies, in Fiji and the Solomon Islands the need for incomes to meet financial, social, cultural and religious obligations, coupled with demographic changes and general economic development, have placed immense pressure on reef resources which local communities depend on for their livelihood. This study confirms that most coastal communities in these two countries are highly dependent on reef resources as their main source of food and income and meeting these needs was the main motivation for local people to go fishing. Nonetheless, in most communities, fishing was also regarded as a way of life and part of their cultural identity. The decline in reef resources now faced by these communities requires government, NGOs and other stakeholders to work closely with communities to develop appropriate reef resource management and livelihood options. All drivers discussed in this chapter play a major role in determining the intensity of harvesting of reef resources. A clear understanding of the different proximate and distal drivers that drives people to fish is essential for the success of proposed management strategies.

5 Chapter 5: Characterizing Livelihood Vulnerability of Communities in Fiji and Solomon Islands to Changes in Reef Resource Availability and Climate Change

5.1 Introduction

The vulnerability approach adopted in this study seeks to understand the complex interaction of biophysical factors and socioeconomic conditions that determines the vulnerability status of households and communities and their ability to cope with or adapt to stressors (Smit & Wandel, 2006; Chen *et al.,* 2014). Vulnerability is a dynamic concept, which can be conceived as an outcome or process, that describes the susceptibility of households or communities to harm in response to a change (Smit *et al.*, 2000; Smit & Wandel, 2006). As explained in chapter 2, this research considers vulnerability to be a function of exposure, sensitivity and adaptive capacity (Smit *et al.*, 2000; IPCC, 2007). These are the product of internal and external processes, which determine the susceptibility of system to harm and its degree of defencelessness when exposed to stresses (Bohle *et al.* 1994).

Vulnerability assessments use a diverse set of methods to systematically examine the interactions between humans and their physical and social surroundings (Hahn *et al.*, 2009). Vulnerability assessments have been used in a wide range of contexts to examine the effects of poverty, famine, health status, biodiversity and globalization (McCulloch & Calandrino, 2003; O'Brien *et al.*, 2004; Birkman, 2006; Füssel, 2007; Bell *et al.,* 2011; Kok *et al.,* 2016; Keshavarz *et al.*, 2017). A common thread is the use of indicators to provide quantitative measures of multidimensional phenomena, which are combined into a composite index (Rygel *et al.*, 2006; Hahn *et al.,* 2009; Amos *et al.*, 2015). In managing vulnerability, it is important to understand the key components of vulnerability, how the components are linked, and how they are affected by external factors (Adger *et al.*, 2004). The advantage of vulnerability assessments is that they focus attention on aspects of adaptive capacity that promote mitigation and adaptation as well as the multitude of interacting factors which may aggravate undesirable impacts (Chen *et al.,* 2014). Vulnerability assessments in tropical coastal areas have focused on how countries (Allison *et al.,* 2009; Hughes *et al.,* 2012), communities (Cinner *et al.,* 2012; Cinner *et al.,* 2013) and diverse social groups (the elderly, migrants and poor people) (Christophe Béné, 2009; Schwarz *et al.*, 2011) differ in levels of exposure, sensitivity and adaptive capacity.

Reef resources in the Pacific region are declining due to impacts of human activities (Hughes *et al.,* 2003; Nelson *et al.,* 2005; Halpern *et al.,* 2008) and climate change (Hoegh-Guldberg *et al.,* 2007; Hoey *et al.,* 2016). Multiple drivers of marine resource use were identified in Chapter 4, while the effects of climate change include principally coral bleaching caused by increasing sea surface temperatures in the region (Burke *et al.*, 2011; Pendleton *et al.,* 2016; van Hooidonk *et al.,* 2016). The scale and nature of climate change and human-induced impacts on communities affect social dimensions of vulnerability (Adger, 2006; Cinner *et al.,* 2013). Thus the exposure of

communities in the Pacific to decreasing reef resources (Kronen *et al.,* 2006; Kronen *et al.*, 2010; Pinca *et al.,* 2012; Bell *et al.,* 2013) could potentially have cascading effects on livelihoods in areas where people are dependent on fisheries.

In this study exposure of households and communities was determined by perceptions and predictions of the rate of decline of local reef resources, while the dependence of households and communities on these resources for their livelihood determined their degree of sensitivity to this decline. While these are important factors in determining vulnerability to any environmental stress, adaptive capacity also has a major influence on the eventual impact of these stresses on households and communities (Brooks *et al.*, 2005). Adaptive capacity is the ability to anticipate and respond to change (Adger & Vincent, 2005), including fulfilment of preconditions that enable adaptation to change (Nelson *et al.*, 2007) and the ability to mobilize and utilize this adaptive capacity when required (Park *et al.,* 2012). Adaptive capacity is largely a function of social and institutional relationships which enable social actors to avoid negative outcomes through mediation among contested interests (Armitage, 2005). and is highly variable across both spatial and temporal scales (Smit & Wandel, 2006). This study considers adaptive capacity as a function of the five livelihood assets employed by the sustainable livelihood framework (SLF, see chapter 2 section 2.2), i.e. social, natural, human, physical and financial capital. The presence or absence of these assets among households and communities affects their capacity to cope and adapt to stresses and, together with exposure and sensitivity, is key to characterizing and determining vulnerability at the local scale.

This remainder of chapter presents and discusses the results of the research and characterizes the vulnerability of communities according to the level of their vulnerability to decreasing reef resources and coral bleaching events based on exposure, sensitivity and the different livelihood assets they have access to.

5.2 Results

5.2.1 Livelihood vulnerability

A bubble plot on a map was used to visualize livelihood vulnerability at the study sites. A vulnerability index was calculated using the indicators for exposure, sensitivity and adaptive capacity, with index values between 0 and 1 where 1 indicates high vulnerability. The overall national vulnerability index was higher in Solomon Islands (mean= 0.65, SD=0.06) than in Fiji (mean= 0.59, SD=0.10), indicating that communities in Solomon Islands were more vulnerable to changes in reef sources and coral bleaching compared to communities in Fiji (Fig. 5.1 and Tab. 5.1). Community vulnerability index values in Fiji ranged from a low score of 0.50 for Tuatua and Nabaka to a high score of 0.75 for Daku. Community vulnerability index values for Solomon Islands ranged from a low score of 0.52 for Nusa Hope to a high score of 0.69 for Rano. In both countries, exposure index values were variable, while in most cases sensitivity

index values were relatively low and adaptive capacity index values were high (Table 5.1). Thus differences in vulnerability were principally determined by levels of exposure, and secondly be differences in adaptive capacity. The low vulnerability index for Nusa Hope in Solomon Islands is due the low level of exposure, while high vulnerability index values for the communities of Dunde, Lodumaho, Kindu, Rano, Vanikuva, Bangopigo and Raromana in Solomon Islands and the communities of Yaro, Ligau and Daku on Kia Island in Fiji can be attributed to the high exposure index values in these communities (Table 5.1).

Table 5.1: The dimensions of vulnerability for the 19 communities in Fiji and Solomon Islands.

Country	Community	Exposure	Sensitivity	Adaptive Capacity	Unweighted average Vulnerability
Fiji	Muaivusu	0.22	0.15	0.86	0.51
Fiji	Nabaka	0.33	0.14	0.56	0.52
Fiji	Namakala	0.31	0.15	0.79	0.53
Fiji	Waiqanake	0.32	0.17	0.82	0.55
Fiji	Ligau	0.48	0.18	0.83	0.72
Fiji	Yaro	0.42	0.18	0.63	0.72
Fiji	Daku	0.49	0.22	0.88	0.75
Fiji	Nakodu	0.32	0.12	0.78	0.52
Fiji	Tuatua	0.28	0.13	0.73	0.50
Fiji	Natokalau	0.31	0.13	0.76	0.52
Solomon Is	Bangopigo	0.49	0.13	0.86	0.66
Solomon Is	Vanikuva	0.49	0.13	0.81	0.68
Solomon Is	Rano	0.50	0.13	0.84	0.69
Solomon Is	Nusa Hope	0.34	0.14	0.89	0.52
Solomon Is	Raromana	0.51	0.13	0.89	0.68
Solomon Is	Dunde	0.46	0.17	0.87	0.67
Solomon Is	Kekehe	0.41	0.13	0.84	0.69
Solomon Is	Lodumaho	0.47	0.12	0.76	0.67
Solomon Is	Kindu	0.40	0.15	0.63	0.67

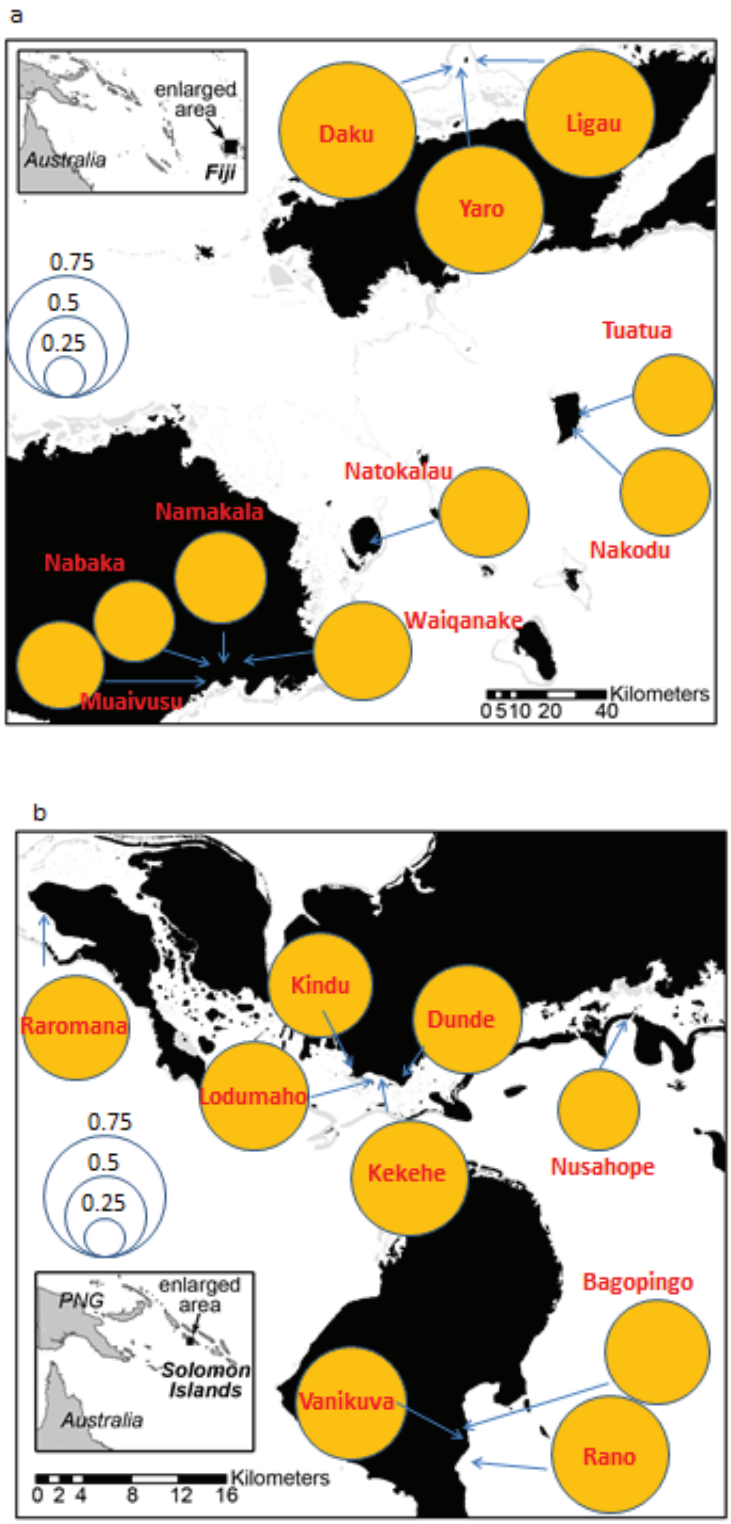

Figure 5.1: Livelihood vulnerability of communities in (a) Fiji and (b) Solomon Islands. The size of the bubbles represents the magnitude of livelihood vulnerability.

5.2.2 Exposure

In this study, exposure was calculated from data on perceptions of reef resources and predicted coral bleaching (see Chapter 3 for details of how the index was calculated). The range of possible values were between 0 and 1. Exposure index values for Fiji ranged from a low score of 0.22 in Muaivusu to a high score of 0.49 in Daku. Values for sites in the Solomon Islands ranged from a low score of 0.34 in Nusa Hope to a high score of 0.51 in Raromana. High values of exposure were obtained for most communities in Solomon Island and the three communities from Fiji located on Kia Island (i.e. Daku, Ligau, and Yaro), indicating a high degree of exposure, while low values were recorded for Nusa Hope in Solomon Islands and the remaining seven communities in Fiji (Table 5.3).

5.2.2.1 Perception of reef resources

Perceptions of reef resources contributed largely to differences in exposure index scores. Most household respondents (i.e. more than 55%) in all the communities in Solomon Islands and the communities of Daku, Ligau and Yaro in Fiji said that reef resources in their fishing grounds were decreasing. In the remaining seven communities in Fiji more than 55% of households stated that reef resources were increasing.

5.2.2.2 Predicted coral bleaching for study sites

Modelled predictions of future coral bleaching showed a pattern of exposure that was remarkably similar to community perceptions of current trends in reef resources (Table 5.2). Overall, the community of Nusa Hope was predicted to be highly susceptible to annual coral bleaching (Table 5.2). Coral reefs at Nusa Hope are expected to be the first to bleach under all four scenarios considered[6], a result which could be attributed to the lagoon system in which that site is located, with a restricted influx of oceanic water. Under scenarios 3 and 4 ('business as usual'), there is a high threat to fisheries in both countries, as corals are predicted to bleach annually in all communities within the next 35 years, starting with the community of Nusa Hope in 2024. Trends in the data across communities were consistent for all four scenarios. Scenario 1 was used in the calculations for this research because the data for this scenario showed the

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[6]

1. Year by which bleaching will happen 10 times per decade (i.e. annual bleaching), under scenario RCP4.5 which assumes emissions stabilize just after 2100 due to successful implementation of climate policies that reduce emissions.
2. Year by which bleaching will happen 2 times per decade under scenario RCP4.5.
3. Year by which bleaching will happen 10 times per decade (i.e. annual bleaching), under scenario RCP8.5 which assumes no climate policies are adhered to (i.e. business-as-usual).
4. Year by which bleaching will happen 2 times per decade, under scenario RCP8.5

highest variability. Under this scenario, Yaro, Ligau and Daku in Fiji and all communities in Solomon Islands were predicted to be affected early on by annual coral bleaching. It is critically important to understand that, irrespective of policies being adhered to or not, coral reefs in these communities are expected to bleach annually within the next 30 years. While, coral bleaching has been reported from both countries in the past, annual severe bleaching would be disastrous for households who depend on reef resources as their main source of livelihoods.

Table 5.2: Years when the onset of annual severe coral bleaching is predicted to occur at the study sites under different scenarios.

Country	Communities	1	2	3	4
Fiji	Muaivusu	2062	2049	2044	2033
	Nabaka	2062	2049	2044	2033
	Namakala	2062	2049	2044	2033
	Waiqanake	2062	2049	2044	2033
	Natokalau	2060	2048	2044	2033
	Tuatua	2068	2059	2052	2044
	Nakodu	2068	2059	2052	2044
	Yaro	2050	2041	2037	2028
	Daku	2050	2041	2037	2028
	Ligau	2050	2041	2037	2028
Solomon	Dunde	2046	2035	2038	2029
	Kekehe	2046	2035	2038	2029
	Kindu	2046	2035	2038	2029
	Lodumaho	2046	2035	2038	2029
	Bangopigo	2053	2041	2040	2032
	Rano	2053	2041	2040	2032
	Vanikuva	2053	2041	2040	2032
	Nusa Hope	2037	2028	2032	2024
	Raromana	2053	2041	2040	2032

Source:CoralReefWatch:
https://coralreefwatch.noaa.gov/climate/projections/downscaled_bleaching_4km/index.php

5.2.2.3 Perceived causes of the decline of reef resources

The main perceived causes of decreases in reef resources in Fiji were overfishing, night diving, traditional fishing and pollution; and, in Solomon Islands, overfishing, use of nets, overpopulation and night diving (Fig. 5.2). While overfishing was perceived as a principal cause of reef resource decline in both communities, there were notable differences in perceptions of other causes between the two countries. In Fiji, 'traditional fishing' was reported as the principal

cause of reef resource decrease, specifically the practice of *yavirau* (community fish drive, see chapter 4 section 4.2.3) in Nakodu, Tuatua, and use of the fish trap in the communities of Muaivusu, Waiqanake, Nabaka and Natokalau. In Solomon Islands, traditional fishing refers to the use of poison leaves. This is still practiced, but was less often reported as a cause of decreasing reef resources than other fishing practices, i.e. the use of nets and night diving Overpopulation was mentioned by a large number of respondents in Solomon Islands, but very few in Fiji, as a contributing factor to the perceived decrease in reef resources. Climate change was not reported by households in either country as a major cause of change in reef resources. People in the studied communities understand climate change as changes in weather patterns which affect crops and lack knowledge of the impacts of climate change on coral reefs. Pollution arising from oil spills, sedimentation, domestic sewage and pigpens was mentioned by a few households in both countries, but logging was hardly mentioned by respondents, even though large-scale deforestation could be observed in Solomon Islands when the survey was being carried out. A chi-squared test was used to test the difference between Fiji and Solomon Islands in the frequency that perceived causes of decrease were mentioned. There were significant differences for use of nets (x^2=43.083, df = 1, p = 0.000), night diving (x^2=4.75, df = 1, p = 0.029), traditional fishing (x^2=38.056, df = 1, p = 0.000) and overpopulation (x^2=42.586, df = 1, p = 0.000).

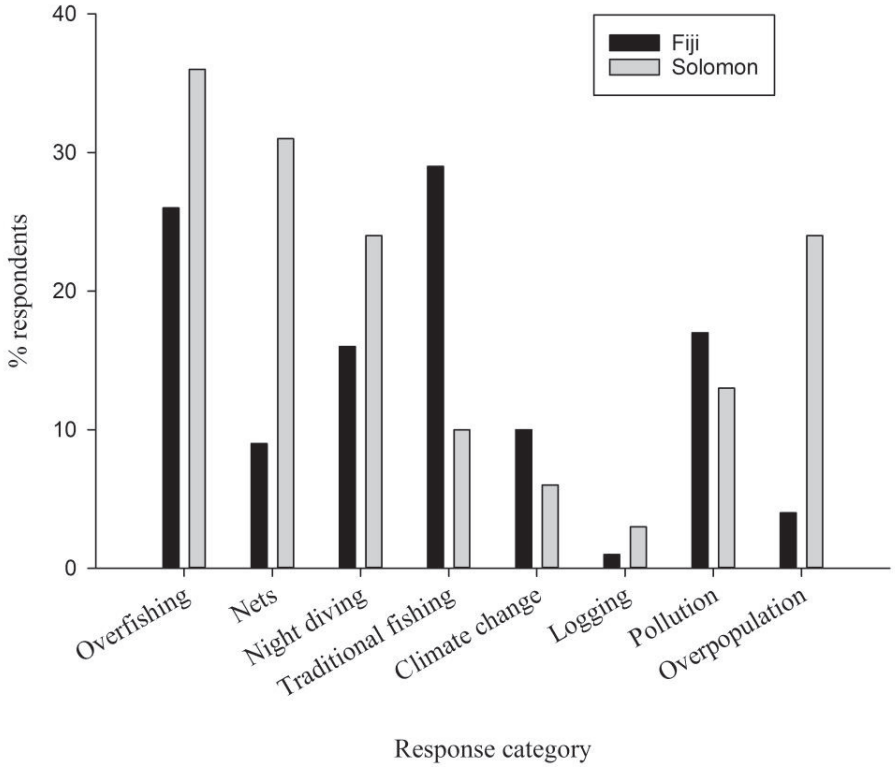


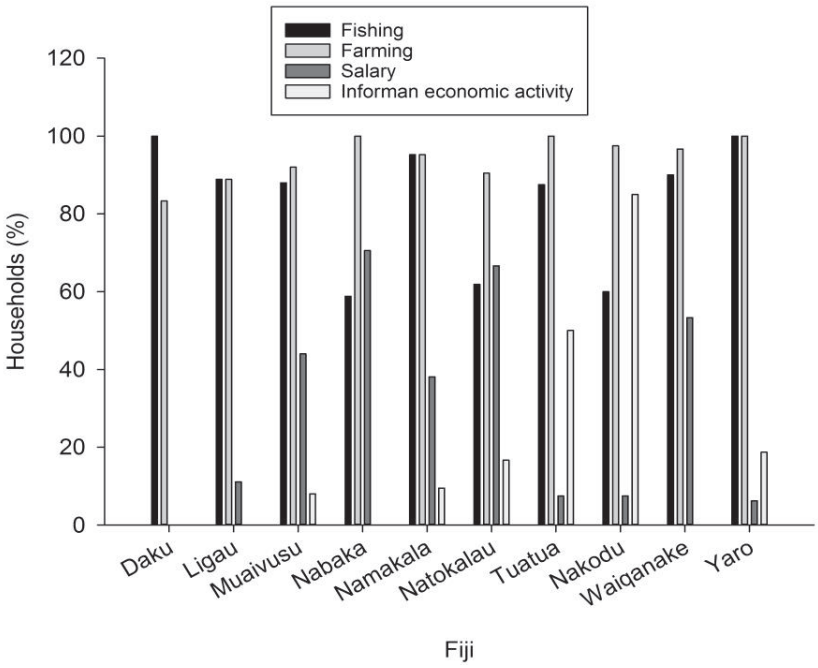
Figure 5.2: Perceived causes of decline in reef resources across communities in Fiji and Solomon Islands

5.2.3 Sensitivity

Sensitivity in this study was measured as reported dependence on reef resources, with values ranging between 0 and 1. There was not much difference in mean sensitivity index values for Fiji and Solomon Islands, which were 0.16 and 0.14 respectively (Table 5.1). These low values reflect the fact that none of the studied communities relied on fishing as their only source of livelihood, with farming contributing significantly to livelihoods in all communities. A Kruskal-Wallis test was used to test if there was a significant difference between the number of households that ranked fishing, farming, salary and 'other informal economic activity' as their main source of livelihood in Fiji and Solomon Islands. The only significant difference was in the number of households that mentioned farming as their main source of income (x^2=17.456, df=1, p=0.000), with farming being significantly less important in Fiji than in Solomon Islands. A Kruskal-Wallis test was similarly used to test if there was a significant difference in the number of households that ranked fishing, farming, salary and other informal economic activity (e.g. small canteen, selling artefacts and handicrafts) as their main source of livelihood among communities in each country. There were significant differences among communities in Fiji in the number of households that ranked fishing (x^2=72.49, df=9, p=0.000) and farming

(x^2=96.928, df=9, p=0.00) as their main income source, and among those in Solomon Islands in the number of households that were engaged in fishing (x^2=54.72, df=8, p=0.000), farming (x^2=26.458, df=8, p=0.001) and informal economic activities (x^2=27.275, df=8, p=0.001). Results showed that more than 60% of households in communities surveyed in Solomon Islands and Fiji were engaged in fishing and farming (Fig. 5.4a and 5.4b). More than 50% of households in the communities of Daku, Ligau, Yaro, Namakala, Nabaka and Waiqanake in Fiji and in Dunde in Solomon Islands ranked fishing as their main source of food and income (Fig. 5.3a and 5.3b). The communities of Kia Island in Fiji (Daku, Ligau and Yaro) were the only communities where some households were totally depended on reef resources for food and income. Their land was not suitable for farming and most of their staple foods were bought from the nearest town. However, families in several communities were totally dependent on non-fishing activities as their main source of livelihood, including many households in Tuatua and Nakodu in Fiji that relied on farming as their main source of income.

a)



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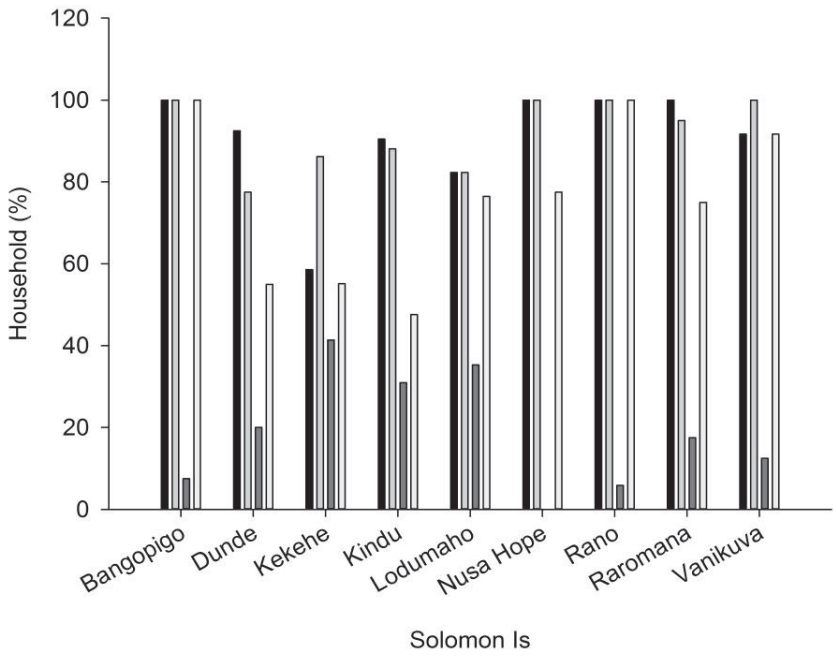


Figure 5.3: Sources of food and income for households in communities in (a) Fiji and (b) Solomon Islands.

5.2.4 Adaptive capacity

Solomon Islands communities had a higher overall average adaptive capacity (mean = 0.82, SD = 0.08) than Fiji (mean = 0.76, SD = 0.1) (Table 5.1). In Fiji, communities of Muaivusu and Daku recorded high adaptive capacities while Nabaka had the lowest score. In Solomon Islands, Nusa Hope, Raromana, Bangopigo and Dunde had high adaptive capacities while Kindu recorded the lowest score. The 10 communities in Fiji and the 9 communities in Solomon Islands displayed variations in most of the adaptive capacity indicators that were measured. Principal component analysis (PCA) showed that differences in overall scores for adaptive capacity in Fiji were driven by variations in community infrastructure, material style of life (MSL), access to credit, human agency and occupational mobility (Fig. 5.4a). PCA for Solomon Islands showed that principal sources of variation were community infrastructure, capacity to change, diversity of fishing gear, access to credit and debt (Fig. 5.4b).

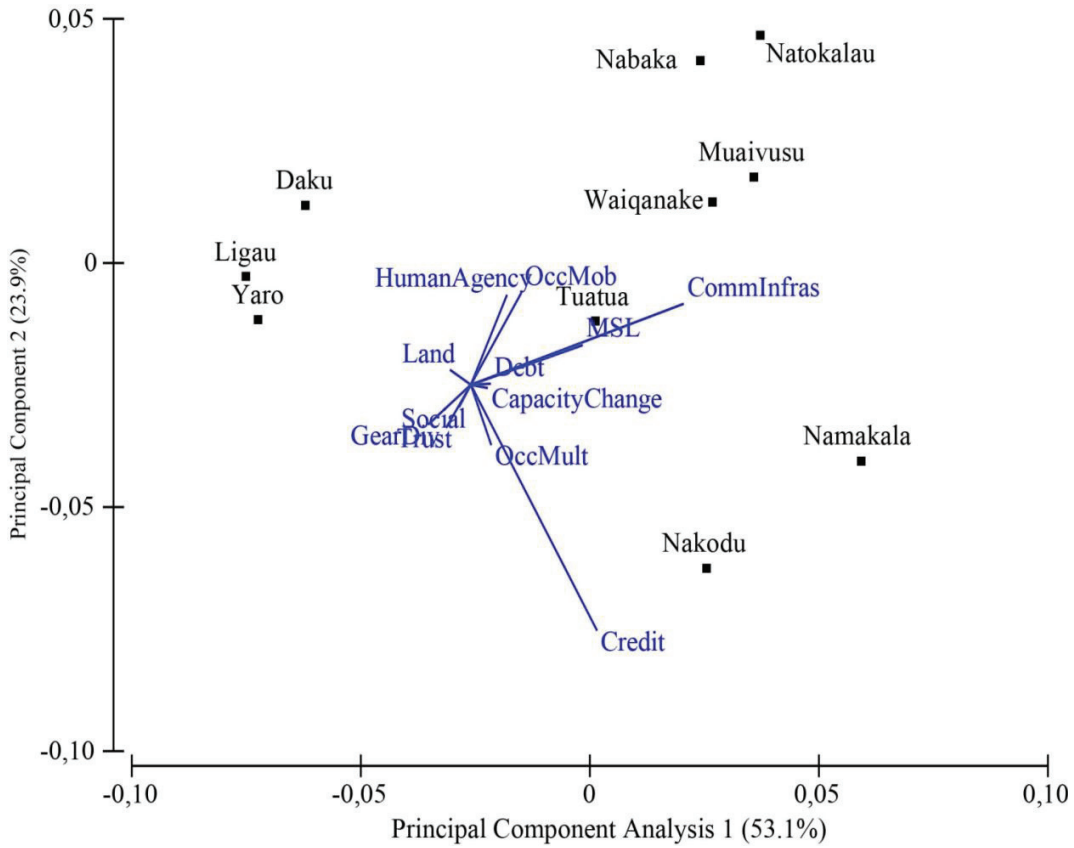
The PCA run on the 12 adaptive capacity indicators for Fiji and Solomon Islands showed that there was a correlation between MSL and infrastructure in Fiji and debt and access to credit in Solomon Islands. Principal sources of variation in adaptive capacity were access to credit, community infrastructure, human agency and occupation mobility for Fiji and capacity to

change, community infrastructure, diversity of fishing gear and access to credit when MSL and debt were omitted from the PCA for Fiji (Appendix Figure A1) and Solomon Islands (Appendix Figure A2) The visual inspections of the scree plots and eigenvalues indicated that first three principal components (PCs) should be retained; these explained 73.5% and 81.3% of the total variation in Fiji and the Solomon Islands, respectively.

In Fiji, human agency, gear diversity, trust, social, credit and debt had substantial loading on PC 1; occupational multiplicity, community infrastructure and land dominated PC 2; and occupational mobility and capacity to change loaded highly on PC 3. Trust, social capital, land and capacity to change loaded negatively on the PCs 1–3 in Fiji (Table A1)

In Solomon Islands, occupational mobility, occupational multiplicity, trust, social capital, access to credit and land had substantial loading on PC1; human agency, fishing gear diversity and MSL loaded highly on PC2; and capacity to change and infrastructure dominate PC3. Occupational mobility, access to credit, human agency and capacity to change loaded negatively on PCs 1–3 in Solomon Islands (Table A2).

a)



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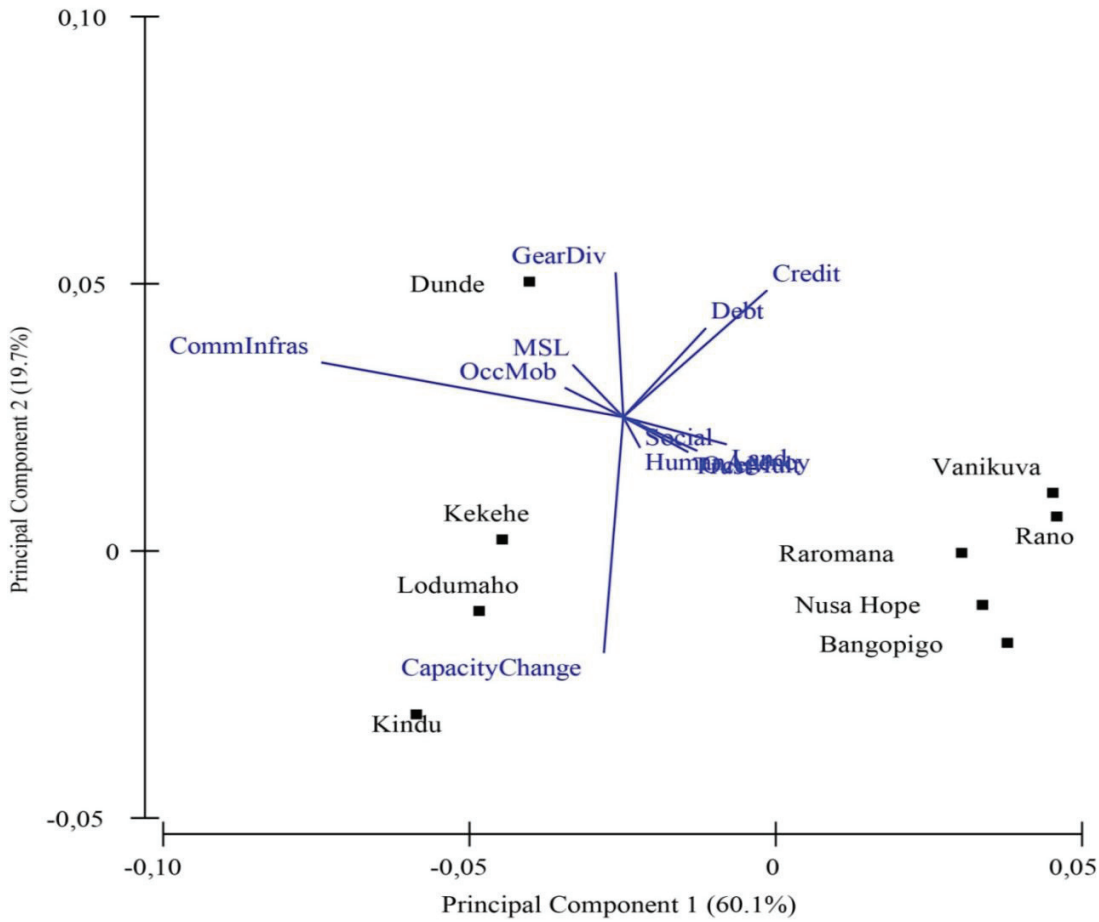
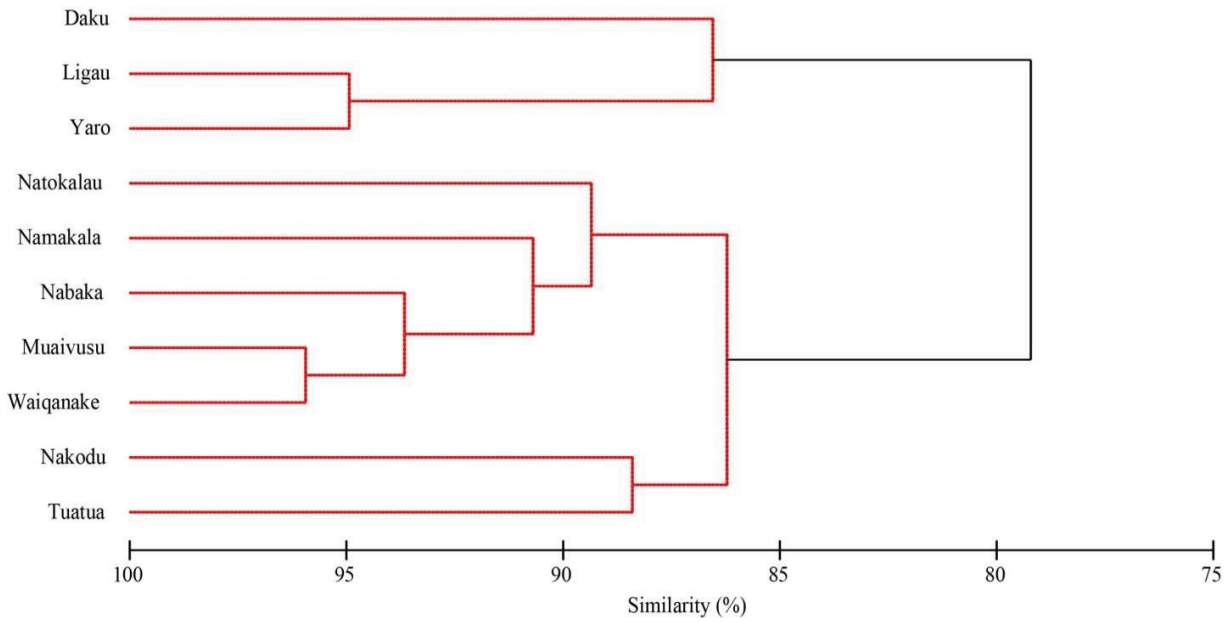


Figure 5.4: PCA of the 12 adaptive capacity indicators analysed at an aggregate community level for (a) Fiji and (b) Solomon Islands. The blue vectors represent the 12 adaptive capacity indicators: Community infrastructure (CommInfras), Debt , Credit , Social , Human Agency, Trust, Occupational Multiplicity (OccMult), Occupational Mobility (OccMob), Land, Fishing Gear Diversity (GearDiv), Capacity to Change (Capacity Change). The black dots represent the communities. Note that to eliminate covariance MSL and debt were omitted from calculation of principal components (PCs) for Fiji and Solomon Islands, respectively.

a) Fiji



b) Solomon Islands

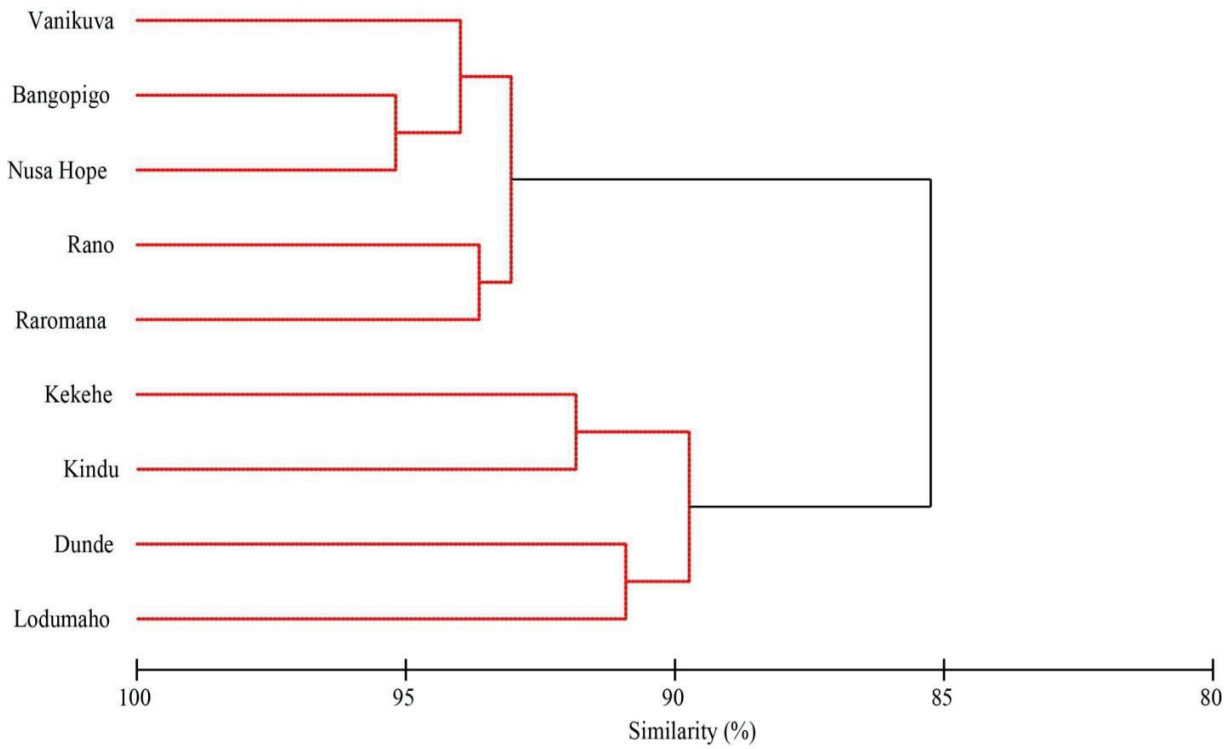


Figure 5.5: Dendograms showing results of permutational cluster analysis of the different communities in (a) Fiji and (b) Solomon Islands, based on the 12 adaptive capacity indicators.

The black lines join groups that significantly differ from each other ($p<0.05$) using the SIMPROF test. The red lines join groups which do not differ significantly from each other.

Permutational cluster analysis and SIMPROF test based on the 12 adaptive capacity indicators confirmed patterns observed in the PCA results. The permutational cluster analysis showed two groupings of communities in each country based on the adaptive capacity indicators which differed significantly from each other ($p<0.05$). In Fiji the communities of Daku, Ligau and Yaro on Kia Island were significantly different (df=9, f=11.1, p=0.001) from the other seven communities (Fig. 5.5a). In Solomon Islands the communities of Nusa Hope, Raromana, Vanikuva, Bangopigo, and Rano were significantly different (df=8, f=10.9, p=0.001) from the four communities located near to Munda, i.e. Dunde, Kindu, Kekehe and Lodumaho (Fig. 5.5b). Visual examination of the PCA (Figure 5.4) indicated that differences in scores for community infrastructure and credit were principally responsible for the groupings of communities in Fiji and Solomon Islands.

5.2.5 Livelihood assets

As further level of analysis, the 12 adaptive capacity indicators were grouped into the five livelihood assets identified by the sustainable livelihood framework, i.e. social, natural, human, physical and financial capital (see Table 3.6 in Chapter 3). The indicators for each of the five livelihood assets were summed at the community level and the average per community for each asset was used in the analysis. Results from the PCA for Fiji and Solomon Islands (Fig. 5.7a and b) showed that physical, financial and human assets contributed most to variability between the communities. For the communities in Fiji, human and physical assets loaded positively while social assets loaded negatively on PC 1 and financial assets loaded positively while natural assets loaded negatively on PC 2. The PCA for Solomon Islands show that natural, social and financial assets loaded positively while physical assets loaded negatively on PC1 and human assets loaded positively on PC 2 (Fig. 5.7b). For both Fiji and Solomon Islands, PC1 grouped communities according to physical assets while PC2 differentiated communities according to financial assets (Fig. 5.6a and b).

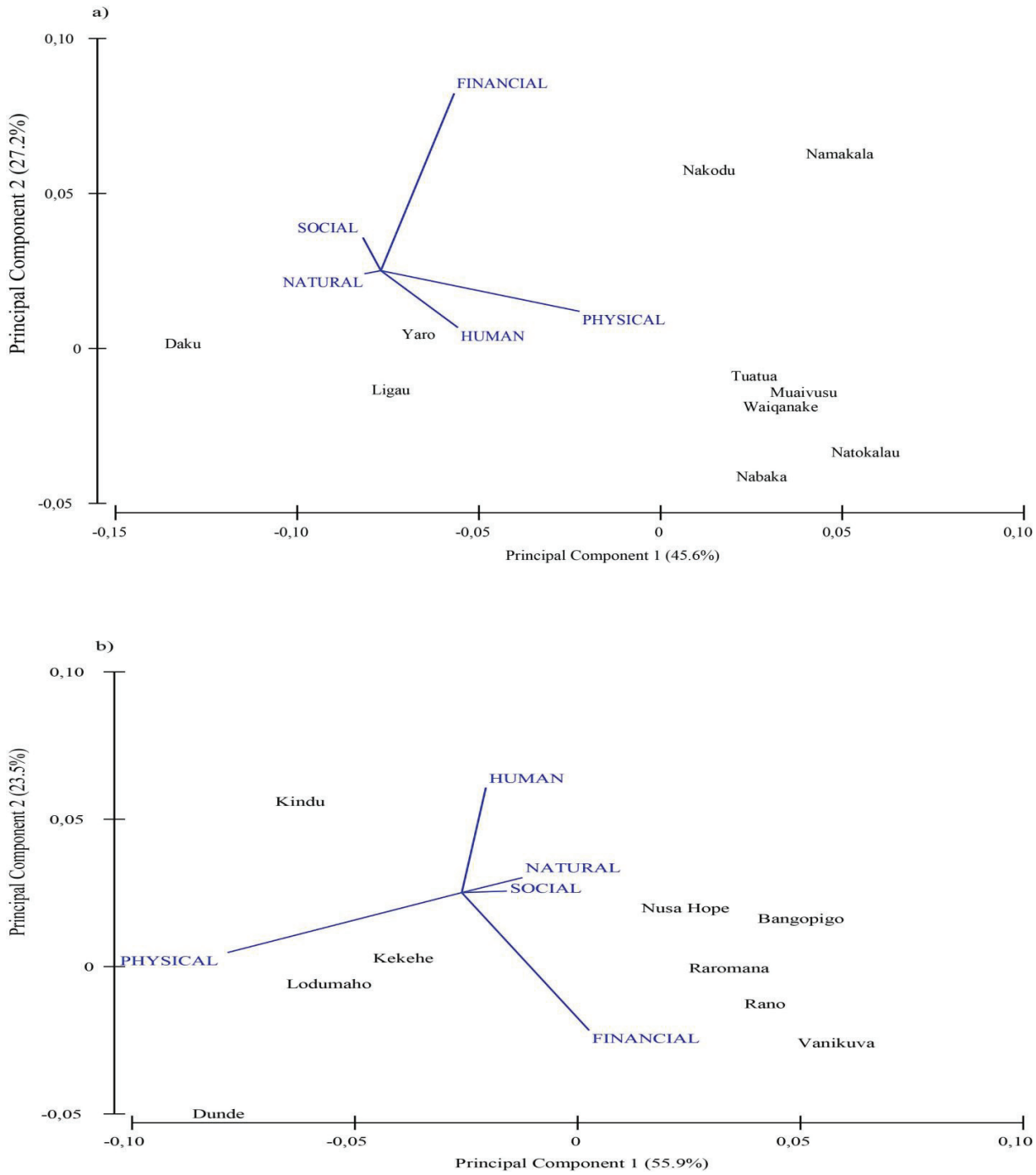


Figure 5.6: PCA of the study communities in (a) Fiji and (b) Solomon Islands based on the livelihood asset values, calculated by grouping 12 adaptive capacity indicators into the five livelihood assets identified by the sustainable livelihood framework (SLF). The arrows displaying the different indicators show which values are driving the distribution of the communities in the plot.

5.2.5.1 Social assets

Trust

The Kruskal Wallis test showed significant difference between Fiji and Solomon Islands in households' level of trust in religious leaders (x^2=74.821, df=1, p = 0.000), government (x^2=5.135, df=1, p = 0.023), NGO (x^2=32.794, df=1, p = 0.000), other village members (x^2=7.149, df=1, p = 0.008), and police (x^2=22.245, df=1, p = 0.000). At the community level, in Fiji, there was a significant difference among communities in the degree of trust in all institutions ($p<0.05$); while in the Solomon Islands, the only institution where differences in the level of trust were not significant was NGOs.

In all the communities in Solomon Islands, households placed greatest trust in religious leaders. Most households in all communities (more than half the number of surveyed households for each community, e.g. 22 households out of 40 households surveyed) reported a moderate degree of trust in NGOs but did not trust people outside their communities. Among individual communities, there were high levels of trust in Bangopigo, Rano, Vanikuva and Nusa Hope in village leaders, village members and NGOs. More than 50% of households in four communities on Solomon Islands stated they did not trust government at all (Appendix Figure A3).

In Fiji, most of the households in the communities surveyed have stated that they did not trust people outside their community. In response to other questions, wide variations were recorded among all communities. For example, there were low levels of trust in leaders and community members in Nabaka and Natokalau and high levels in Daku, Ligau and Yaro. Only one household out of 17 in Nabaka trusted leaders and community members, while in Natokalau, only 8 households from the 42 surveyed households trusted community members. By contrast, in the communities of Ligau, Daku and Yaro on Kia Island, 24 of the total of 31 households surveyed in these communities trusted leaders and community members. Households in these three communities also trusted government and NGOs more than those in any of the other communities (28 of the 31 surveyed households). More than 50% of households in Muaivusu, Nabaka and Waiqanake mentioned that they place moderate trust in religious leaders while more than 80% of households in the other seven communities in Fiji trusted religious leaders (Appendix Figure A3).

Community network

More than 50% of households in 8 out of 10 communities in Fiji and 7 out 9 communities in Solomon Islands belong to a committee (Fig. 5.7). The percentage of households that belong to a committee was highest in Daku in Fiji and Rano in Solomon Islands, but this could be due to the small size of these two communities. Respondents were also asked whether they were members

of a marine resource committee. Responses revealed that in most communities, in Fiji and Solomon Islands, only a few households are members of the marine resource committee, which typically comprises fewer than ten individuals. The involvement of households in a committee does not guarantee active participation in decision making. More than 60% of households from communities in the Solomon Islands reported that they do not participate in any community decisions (Appendix Table A3). In Fiji, by contrast, more than 50% of households actively participate in community decision making (Appendix Table A4).

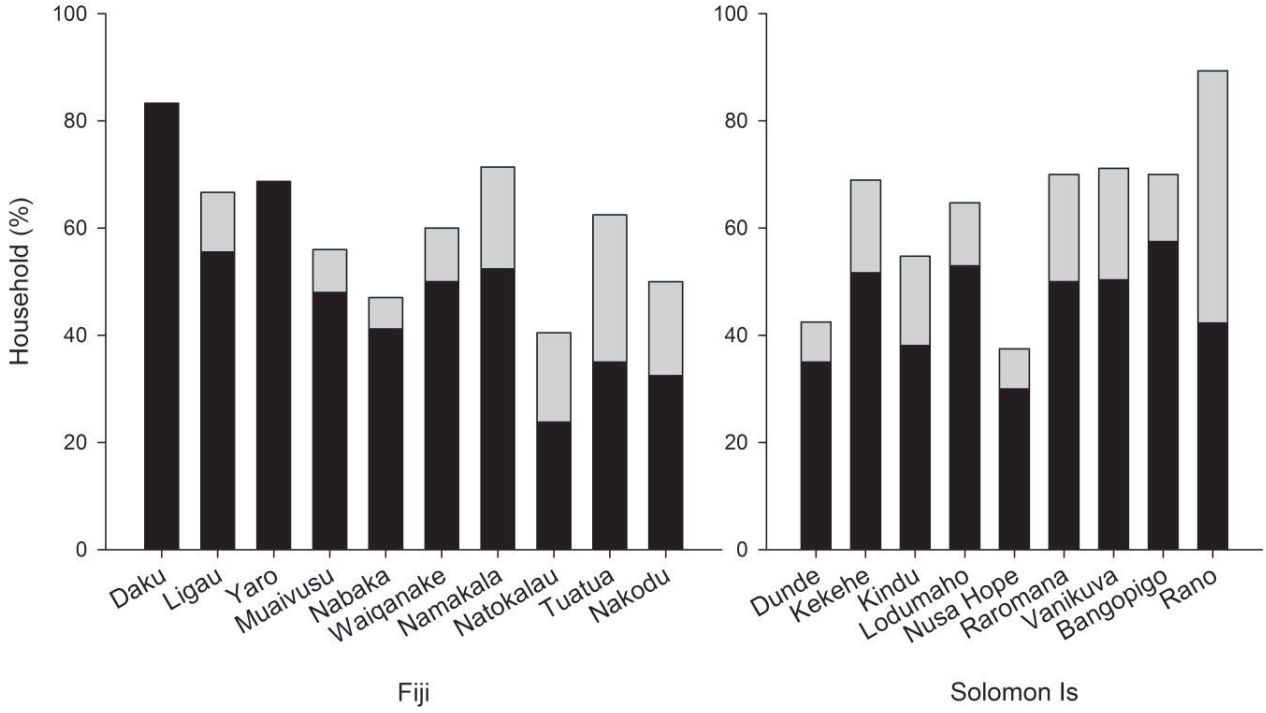


Figure 5.7: The grey and black bars show the total percentage of households in Fiji and Solomon Islands that belong to a committee. The grey bars show the percentage of households that belong to a marine resource committee.

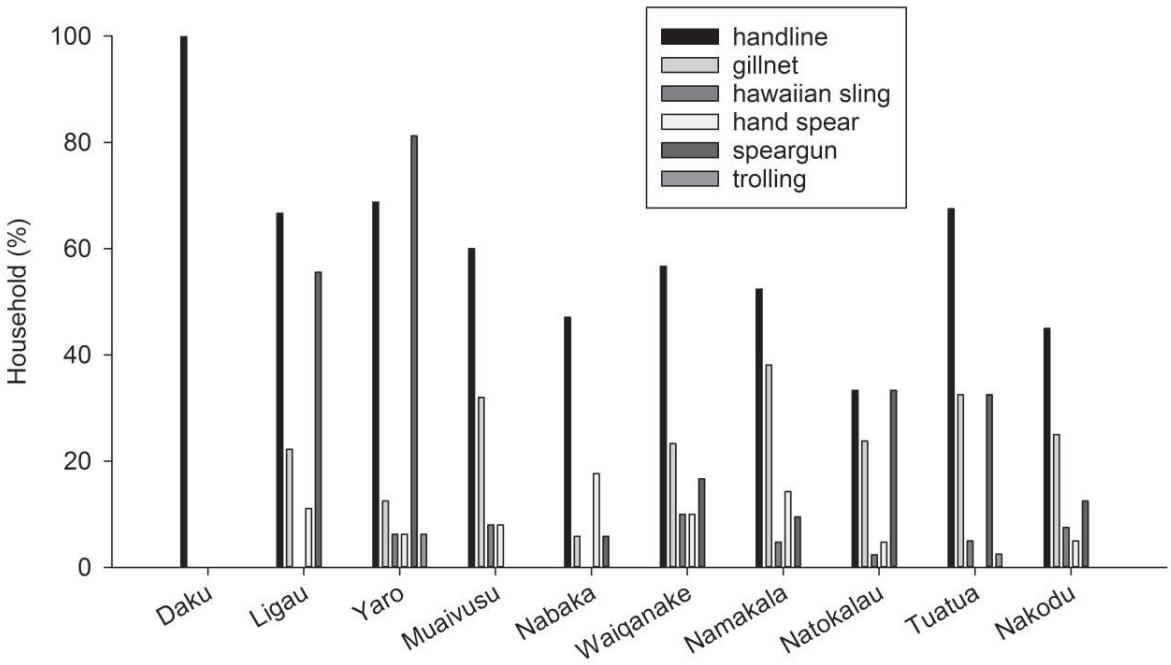
5.2.5.2 Physical assets

Fishing gear diversity

The most common fishing gear used throughout the study communities were handlines (Fig. 5.8). Other frequently used fishing gear included speargun and gillnet in Fiji, and trawl net, Hawaiian sling and gillnet in Solomon Islands. Daku in Fiji was the only community where only one fishing gear was used (handline), while other communities used more than one fishing gear. A chi-squared test was performed to test if there were any significant differences between Fiji

and Solomon Islands and among communities in the frequency of use of particular fishing gears. There were significant differences between Fiji and Solomon Islands for handline (x^2=8.621, df=1, p=0.003) and speargun (x^2=25.693, df=1, p=0.000) There were significant differences among communities in Fiji for handline (x^2=31.460, df=9, p=0.000) and gillnet (x^2=21.005, df=9, p=0.007); while in Solomon Islands there was a significant difference only in the use of handline (x^2=20.406, df=8, p=0.009). Analysis at the household level confirmed that most households in Fiji and Solomon Islands used handline as their main fishing gear. Even though few households used spearguns in both countries, there were more households that used spearguns in Fiji than in Solomon Islands. Gillnets were mostly used by households in the communities of Namakala, Muaivusu and Tuatua in Fiji (Fig. 5.8). Fishing in Fiji was often done by walking or swimming to the reef or by travelling to the reef in motorized fiberglass boats. The community with the highest number of motorized fishing boats in Fiji was Yaro, which had 19 boats, while all other communities in Fiji had at least one boat with an engine. In Solomon Islands, most fishing was done using dugout canoes and almost every household surveyed in Solomon Islands owned a canoe, which were also used for trawling for reef and pelagic fishes. Canoes were no longer used by communities studied in Fiji and trawling in Fiji was an expensive exercise because it was most often done using a motorized fiberglass or wooden boat.

a)



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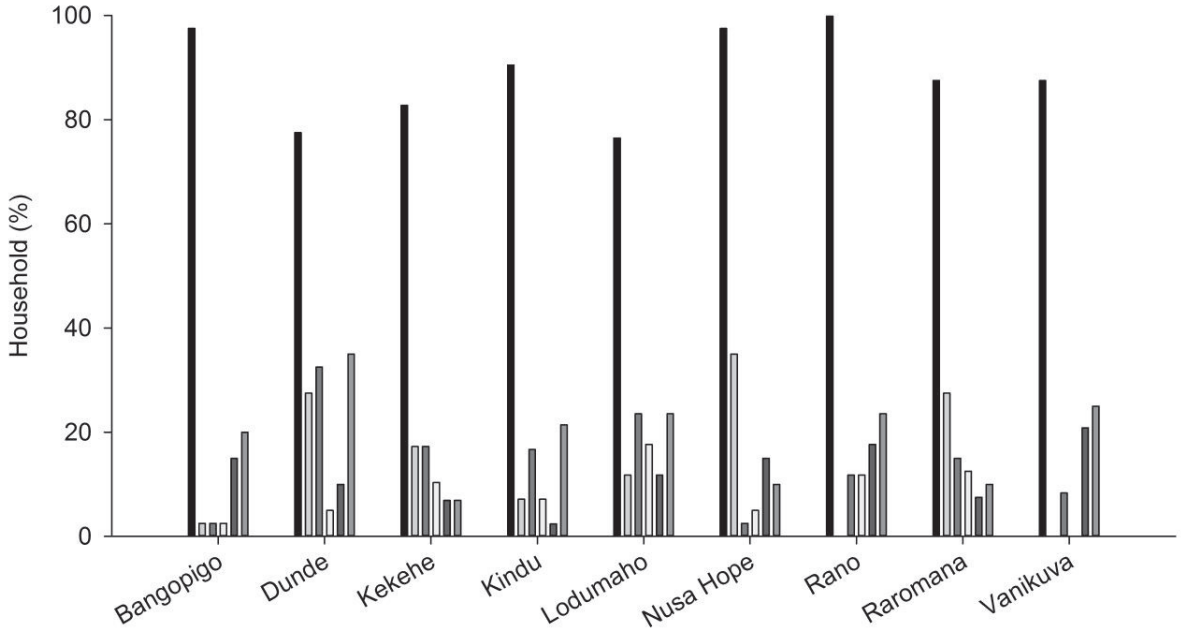


Figure 5.8: The different fishing gears used by households in (a) Fiji and (b) Solomon Islands.

Community infrastructure

Twenty indicators of infrastructure[7] were measured in this study. In both countries there was a sharp contrast between communities that had a broad range of infrastructure items (seven out of 10 in Fiji, but only four out of nine in Solomon Islands) and others where infrastructure was minimal. In Fiji, Natokalau had the highest overall number of infrastructure items present while the Kia Island communities of Daku, Ligau and Yaro had the lowest numbers (Table 5.4). The communities of Daku, Ligau and Yaro did not have access to roads and lacked a proper water source and health care facilities; in fact the only two infrastructure items in Daku, Ligau and Yaro were a primary school and telephone. All communities in Fiji have access to telephones, unlike in Solomon Islands, where the communities of Rano, Bangopigo and Vanikuva have no access to telephones. In Fiji, banking facilities were only available to the communities of Natokalau, Muaivusu, Nabaka, Waiqanake and Namakala due to the close proximity of these communities to town centres. The communities of Muaivusu, Nabaka, Waiqanake and Namakala had access to treated water, which had recently been installed by the Fiji Water Authority.

[7] The 20 infrastructure items measured were presence of; hospitals, medical clinics, doctor, nurse, primary school, secondary school, piped water, sewer pipes, sewer treatment, septic tanks, food markets, pharmacy, guest house, public transport, gravel or sealed road, bank, gas station, dentist, telephone, electricity

Access to water in these communities had been a major problem for years, even though they are near the capital city of Suva. There was also tap water in the communities of Natokalau, Tuatua and Nakodu but the water was not treated.

Overall fewer infrastructure items were present in communities in Solomon Islands, compared to those in Fiji. The communities of Dunde, Lodumaho, Kekehe and Kindu in Munda area in Solomon Islands had the highest number of infrastructure items; for example, banking and health care facilities were only available to these four communities. However the four communities in Munda all lacked a proper water supply, using bore holes and water tanks as their main source of water, as in the communities of Raromana and Nusa Hope. Vanikuva, Rano and Bangopigo had access to tap water, however the water was not treated. Rano had the lowest infrastructure index in Solomon Islands, with only one of the indicator items present, i.e. a primary school. Nusa Hope, Raromana, Bangopigo, Vanikuva and Rano also had very low numbers of infrastructure items (Table. 5.3). The remoteness and isolation of these communities was the reason for the comparative lack of infrastructure items.

Table 5.3: The total number of infrastructure items present in the study communities and all items given the same weight.

Country	**Community**	**No of infrastructure items present**
Fiji	Daku	2
Fiji	Ligau	2
Fiji	Muaivusu	16
Fiji	Nabaka	16
Fiji	Nakodu	11
Fiji	Namakala	16
Fiji	Natokalau	17
Fiji	Tuatua	11
Fiji	Waiqanake	16
Fiji	Yaro	2
Solomon	Bangopigo	3
Solomon	Dunde	14
Solomon	Kekehe	14
Solomon	Kindu	14
Solomon	Lodumaho	14
Solomon	Nusa Hope	2
Solomon	Rano	1
Solomon	Raromana	3
Solomon	Vanikuva	3

Material style of life

The material style of life (MSL), as indicated by the housing structure (i.e. the type of construction), infrastructure and possession of furniture and other household items provided an indication of the relative wealth or social status of a household in a community (Pollnac & Crawford, 2000). According to the MSL indicators, households in Fiji have a higher 'material style of life' compared to households in Solomon Islands. In Solomon Islands, there were more household items observed in the communities of Kekehe, Dunde, Kindu and Lodumaho compared to the other communities in Solomon Islands. These four communities are near Munda town where there is an airport and port for ships that transport goods from Honiara.

Table 5.4 shows the MSL items which varied the most between Fiji and Solomon Islands. Communities in Fiji and Solomon Islands differed in ownership of household items, water source and sanitation. 'Modern utilities' (Table 5.4) were more prevalent in Fiji, while 'old fashioned' technology was more common in Solomon Islands. For example, all the houses in Fiji were either made from plank wood, concrete and/or roofing iron; none had thatched roofs. In Solomon Islands, while most houses had plank wood walls, more than 50% of the houses in Bangopigo, Vanikuva, Kindu, Nusa Hope and Rano had thatched roofs. As mentioned above, none of the households surveyed in Fiji owned a canoe, unlike in Solomon Islands where almost all fishing households owned a canoe. Most households in Fiji had access to mains electricity, piped water supply (although not always treated, as explained above) and proper sanitation. By contrast, most households in Solomon Islands used solar power and possessed a water tank to store rainwater. Moreover 50% of the households surveyed in Solomon Islands had no toilet and used the beach for defecation (Table 5.4). More than 80% of households in Rano and Raromana and about 70% of households in Bangopigo and Vanikuva had no toilet.

The higher number of infrastructure items present in Fiji enabled households to acquire and use a wider range of material items (i.e. consumer goods of various kinds). A comparison of mean MSL composite scores based on the twenty five items assessed (Table 5.4) showed that households differed significantly between Fiji and Solomon Islands ($t(533)=14.145$, $p<0.005$).

Table 5.4: Percentage distribution of the 25 material items for Fiji and Solomon Islands.

Item	Fiji (%)	Solomon (%)
Light bulb	89	11
Wall plank wood	13	3
Kerosene stove	64	0
Water piped	87	17
Canoe	0	77
TV	51	4
Solar	27	86
Electricity	76	15
Water tank	14	72
Floor plank wood	46	93
DVD	39	3
Floor cement	42	7
Flush toilet	44	7
No toilet	2	51
Wall cement	32	2
Iron	27	1
Water creek	54	6
Radio	38	6
Fridge	19	2
Washing machine	13	0
Table	30	84
Wall metal sheets	37	1
Toilet water seal	54	41
Cupboard	34	30
Gas stove	16	9

5.2.5.3 Financial assets

Most households from Fiji and Solomon Islands have access to credit; however, few households were in debt (Fig. 5.9). It was evident from the interviews that household obtained credits from local shops or families and not from banks or other financial institutions. Therefore debts, when incurred, are small and are often paid back within one or two weeks. Access to credit at shops was often used for the purchase of basic food and household items such as sugar, oil, salt and washing supplies. In three communities in Solomon Islands, Bangopigo, Vanikuva and Rano, access to cash was difficult, thus it was still possible to buy goods in shops with coconuts. A respondent from the household interviews said that 10 coconuts can be given to a shop keeper in exchange for a bar of soap. These coconuts were processed by shop owners into copra and sold

to the boat which visits the community once a month. Households that own a large number of coconut trees were considered wealthy by the people in these three communities.

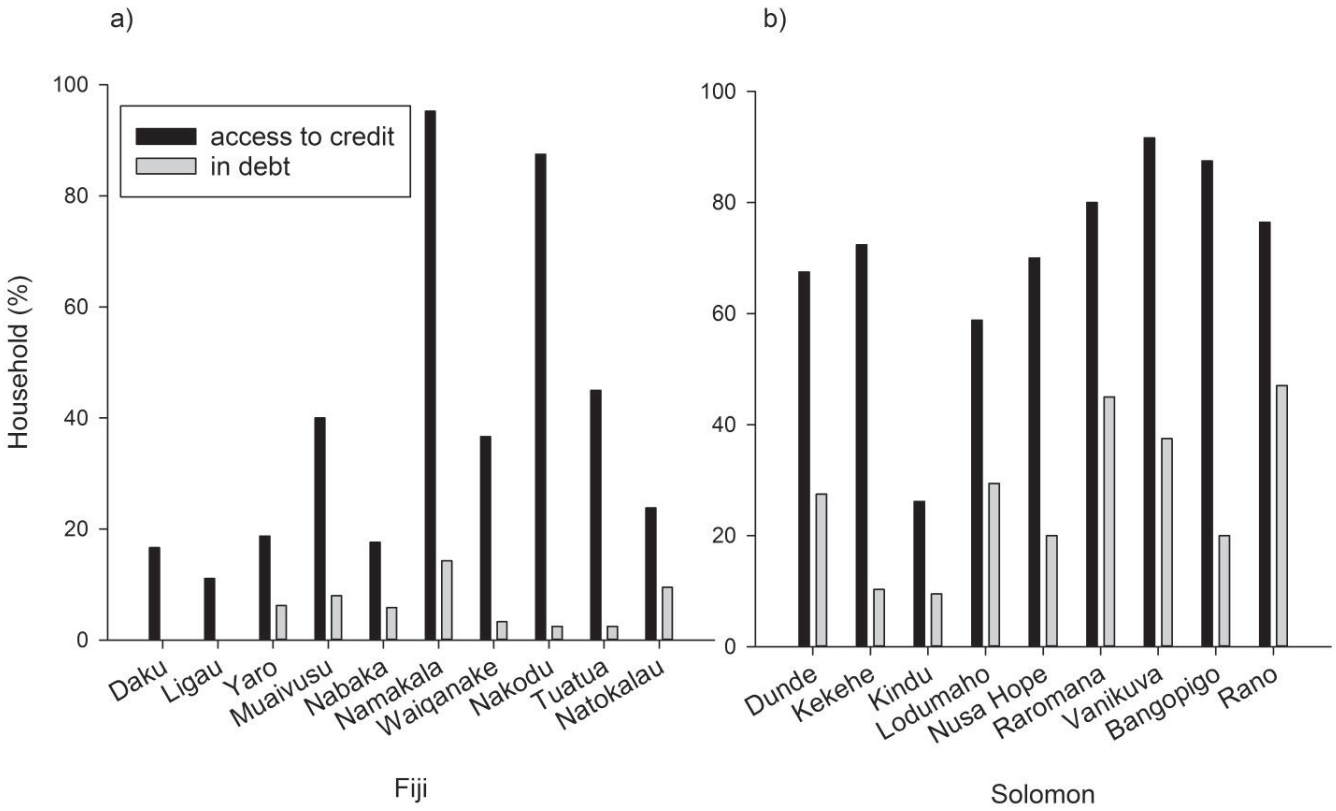


Figure 5.9: The percentage of households that had access to credit and were in debt.

5.2.5.4 Natural assets

Most respondents from the household interviews in Fiji and Solomon Islands said that they own land in their communities (Fig. 5.10). While there were some households that owned land but were not engaged in farming, for most households access to land was important as a major source of food and income, in addition to reef resources. Results from household interviews and FGDs indicated that households that do not own land were given land to farm by land-owning clans. It was often men from other communities that married locally and decided to live in their wife's community that did not own land. In Fiji, farming was often done by men; while in the Solomon Islands it was interesting to learn that most women were involved in farming. In the communities of Vanikuva , Rano and Bagopingo, women reported that they do the farming and they work in groups to reduce their work load, while men go fishing or stay home.

"We farm here in Bangopigo while men go fishing or even just stay home. Men are lazy and if we do not farm we will not eat and we are the ones that suffer." (R. S., Bangopigo, 16/04/2015)

The crops planted by households in Fiji and Solomon Islands were mostly the same except for *kava* (*Piper methysticum*), which was only planted and consumed in Fiji, where it was a major source of income for communities and also possessed cultural significance. Nakodu and Tuatua were the only communities from Fiji that produced *taro* as an export crop for sale on overseas markets and there were no export crops in Solomon Islands. Other communities in Fiji farmed for household consumption only, while most households in Solomon Islands consumed some of the food produced and also sold their farm produce in nearby communities or at the nearest market (see Table 4.6 in Chapter 4).

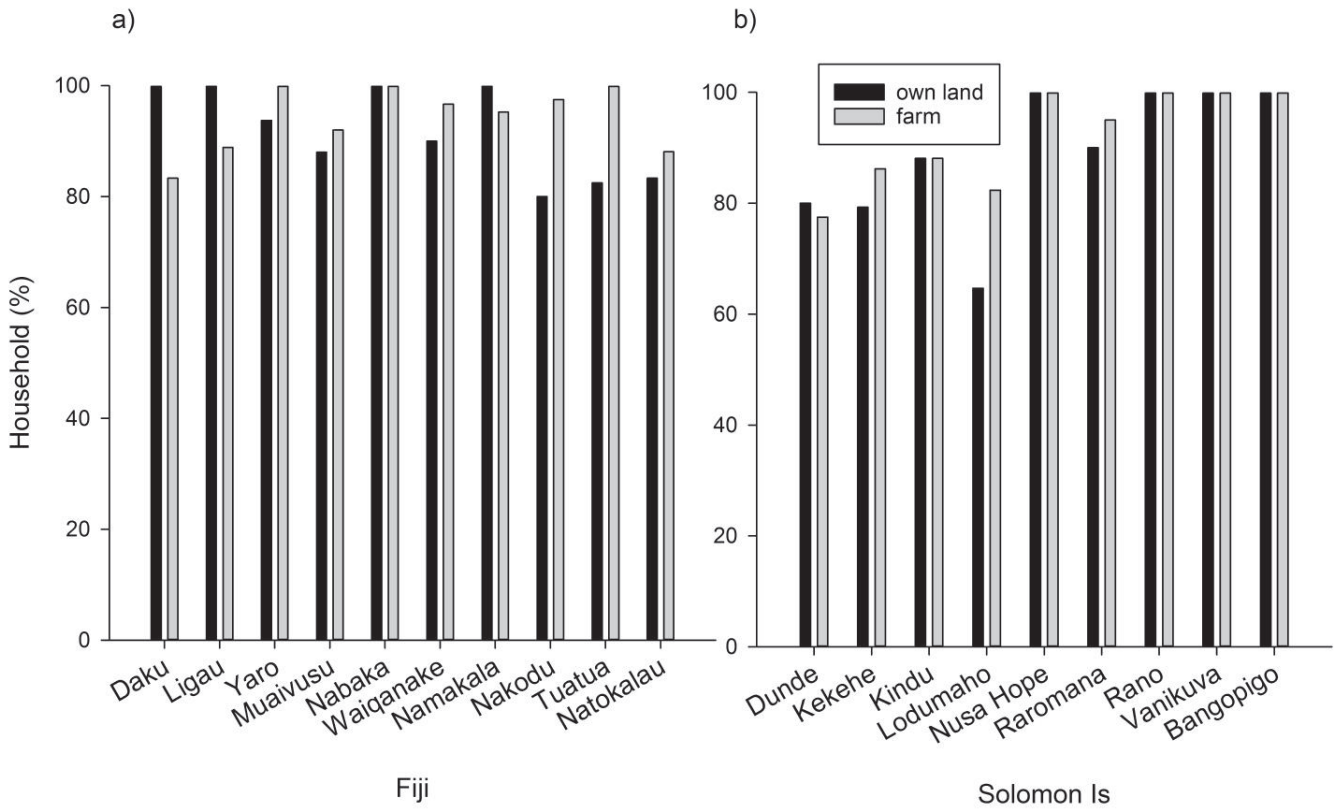
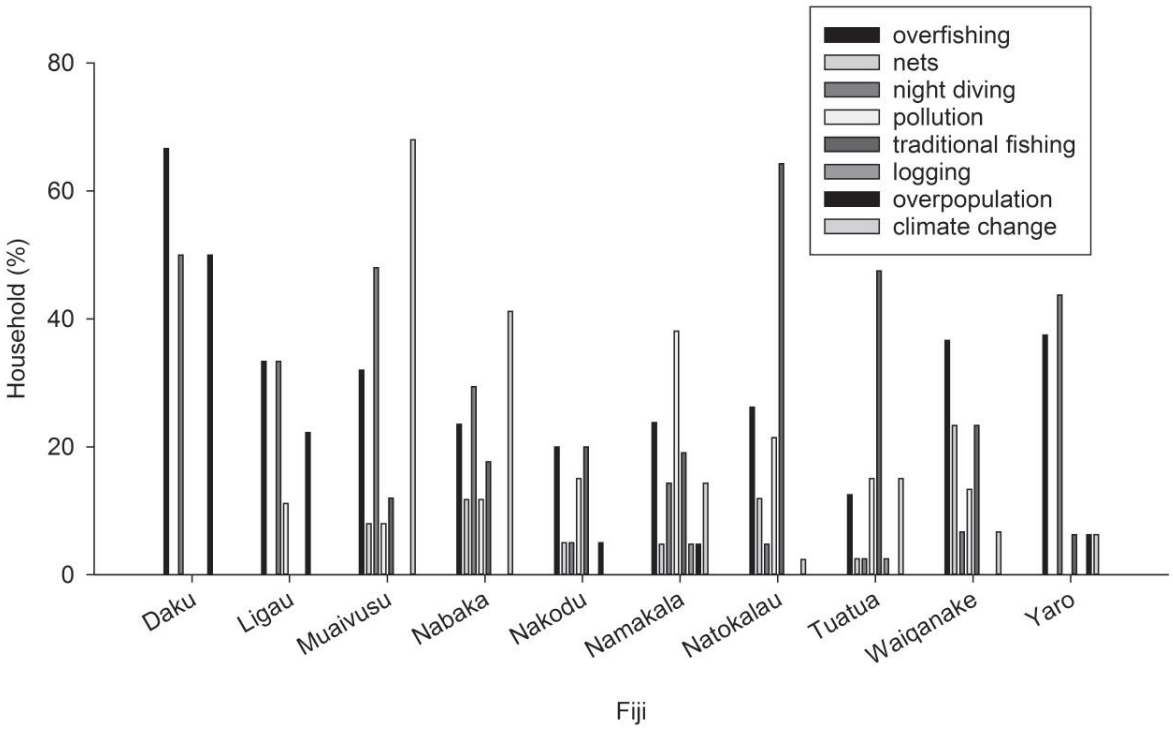


Figure 5.10: The percentage of households that own land and do farm in Fiji and Solomon Islands.

5.2.5.5 Human assets

Human agency

Human agency was measured by households' ability to identify causal factors impacting on reef resources. A total of 87% of households in Fiji and 92% of households in Solomon Islands mentioned (single or multiple) factors they perceived as affecting reef resources. These results are summarized in Section 5.2.4 above; Fig. 5.11 shows the breakdown of responses for each community, and reveals a wide variation in perceptions of the causes of reef resource decline among communities.



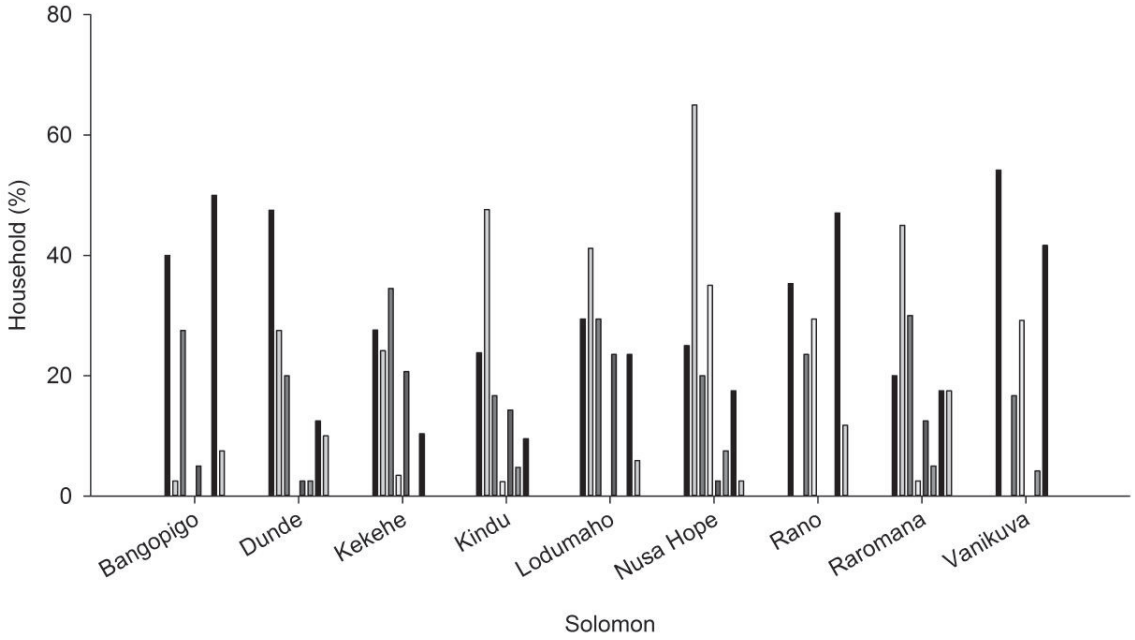


Figure 5.11: Percentages of households in (a) Fiji and (b) Solomon Islands who mentioned different causes of the decrease in reef resources.

Capacity to change

A total of 46% and only 19% of households respectively in Solomon Islands and Fiji stated that they could leave the fishery and engage in other livelihood activities. Dunde had the lowest percentage of households in Solomon Islands with the capacity to adopt alternative livelihoods. In Fiji, in eight of the 10 communities, fewer than 20% of households indicated they could engage in other livelihood activities. An in-depth analysis on the different livelihoods options people have access is provided in chapter 6.

Occupational mobility

Most households that were interviewed in Fiji had not previously engaged in any formal work apart from being a fishermen or a farmer in the community. The only community in Fiji where 50% of households had previous experience of formal employment was Natokalau, where some respondents previously worked at the Pacific Fishing Company[8] (PAFCO). In two communities in Fiji between 10% and 20% of households, and fewer than 10% of households in the remaining

[8] Pacific Fishing Company (PAFCO) is a tuna cannery based in Ovalau, the island where the community of Natokalau is located

seven communities had previous experience of formal employment. In Solomon Islands there were more respondents with previous experience of formal employment than in Fiji: more than 40% of households in Dunde, Kekehe and Kindu and 35% of households in Lodumaho and Rano had previously engaged in formal work. More households in Dunde, Kindu, Kekehe and Lodumaho were engaged in formal work because these communities are located close to the urban centres of Munda and Noro. In general, occupational mobility was higher in Solomon Islands than Fiji.

Occupational multiplicity

Most households in Fiji and Solomon Islands were engaged in at least two occupations, i.e. farming and fishing; however, some households relied on salary and other informal economic activities as well. Few households from both countries relied on only one occupation for food and income. Communities in Fiji and Solomon Islands had an average of 2.7 ± 1.7 and 3.6 ± 1.9 occupations per household, respectively (Appendix Table A 5). Communities in Solomon Islands were engaged in informal economic activities to a greater extent than those in Fiji (Figure 5.3c and d). These informal activities included the sale of coconuts, copra, mats, pastries (such as buns, donuts, scones, and pancakes), cigarettes and beetle nuts, and ownership of canteens and other small businesses. In Fiji informal economic activities were mainly observed in the communities of Nakodu and Tuatua, where households sent commodities such as coconuts, dried pandanus leaves and mats to the market in Suva.

5.3 Discussion

5.3.1 Vulnerability of communities

The assessment of the vulnerability of households and communities to the impacts of decreasing reef resources and coral bleaching in this study was conducted using locally relevant indicators of exposure, sensitivity and adaptive capacity. Understanding how these components of vulnerability and their indicators interact and how this influences the vulnerability of households and their livelihoods is important for effective reef resource management. Communities in Fiji and Solomon Islands that had high exposure indices and depended on reef resources for livelihoods were not highly vulnerable because low levels of sensitivity and a moderate degree of adaptive capacity partially offset this exposure. However, the exposure of communities to climate-related reef degradation such as coral bleaching would further aggravate the decline in reef resources that already perceived by resource users.

The findings from this study indicated that seven out of nine communities in Solomon Islands (Dunde, Lodumaho, Kindu, Raromana, Rano, Bangopingo and Vanikuva) and three out of ten communities in Fiji (Daku, Ligau and Yaro on Kia Island) were highly vulnerable to decreasing

marine resources and coral bleaching. The high indices of vulnerability observed for these communities reflected high levels of exposure and/or low adaptive capacity. For example Kindu had a relatively low exposure index but its low adaptive capacity index increased its level of vulnerability.

It could be argued that the approach of measuring exposure based on a survey of resource users' perceptions provided biased results, since no ecological data was available to confirm the findings of household interviews; however respondents in FGDs and KIIs in all these 10 communities also reported that reef resources in their fishing grounds have decreased compared to previous years.

Many other studies have used ecological data and coral bleaching data (i.e. ecological surveys of coral and fish colonies) to measure exposure when assessing livelihood vulnerability (Badjeck *et al.*, 2010; Bennett *et al*, 2014; Cinner *et al.*, 2012; Islam *et al.*, 2014), which this study lacked. This study adopted a different approach, combining data based on perceptions of reef resources and modelled predictions of the frequency of coral bleaching, and as such was the first integrated vulnerability study to be conducted in Fiji and the Solomon Islands. Results indicated that current high levels of exposure to (perceived) decreasing reef resources would likely be further increased but the onset of annual bleaching of corals predicted by the climate models.

People's perceptions of natural resources determine how a resource is utilized and its relative value to the community (Cinner & Pollnac, 2004). The communities in Fiji and Solomon Islands value reef resources highly as a source of food and income and it was notable that in seven communities in Fiji there was a perceived increase in reef resources, due to the existence of a *tabu* area in their fishing grounds. FGD participants and KIs from these seven communities reported that the decrease in catch and size of fish led to the establishment of these *tabu* areas, and most respondents reported that catch and size of fish had increased following their establishment. Moreover communities of Kindu, Kekehe, Lodumaho and Dunde in Solomon Island and those of Ligau, Daku and Yaro in Fiji had *tabu* areas in the past and it was reported during FGDs and KIIs that fish catch and size had improved when the *tabu* areas were in place. Conversely, the opening up of the *tabu* areas in Ligau, Daku and Yaro was reported to have contributed to a decrease in size of fish (Jupiter, *et al.*, 2012). *Tabu* areas could reduce fishing pressure (Cohen *et al.,* 2013), increase the abundance of fish (Harrison *et al.*, 2012) and increase the resilience of coral reefs to natural disturbances such as coral bleaching (Mellin *et al.*, 2016).

Tabu areas were also the management measure most widely suggested by informants. Focus group participants and KIs from Solomon Islands and Fiji stated that the re-establishment of *tabu* areas could assist in increasing their catch. However, *tabu* areas are not always effective. In Solomon Islands, Nusa-Hope has an existing *tabu* area but respondent reported it was only partially complied with, while the *tabu* area in Lokuru was far away from the communities where benefits could not be experienced by fishers. Even though Nusa Hope had the lowest index for exposure, Nusa Hope was highly susceptible to annual coral bleaching under the 4 scenarios

(section 5.2.2.2). The low value for exposure could be due to the calculation of the indices where an index for coral bleaching and respondents' perception on reef resources were used.

Kolding *et al.* (2014) argue that people can only perceive their own daily catch but not the accumulated catch of the whole fishery. More research on catch per unit effort and a fish stock assessment is thus needed to fully understand the perceived decrease in reef resources and its causes to enable effective management of reef resources in Fiji and Solomon Islands. The decrease in catch per unit effort is a possible indicator of overfishing (Kolding *et al.*, 2014). Kolding *et al.* (2014) and such studies could therefore contribute to effective fisheries management that mitigates the effects of over-fishing. For example Kolding *et al*. (2014) suggest that a ban on use of non-selective fishing gear such as nets could mitigate or stop the reduction in size of fish caught. However, the results of this study indicate that, in the longer term, the predicted frequency of coral bleaching events in all the surveyed communities of Solomon Islands and communities of Daku, Ligau and Yaro in Fiji under scenario 4 (i.e. twice per decade; Table 5.2) would exacerbate the perceived decline in reef resources that communities were already experiencing. These threats to coral reefs, in turn, pose serious risks to the livelihoods of people, households and communities in Fiji and Solomon Islands who depend on coral reef resources for food, income, recreation and protection against storms and waves (Burke *et al.*, 2011).

Results on sensitivity from this study showed communities in Fiji and Solomon Islands do not depend entirely on reef resources for food and income and therefore sensitivity indices were low. While overall sensitivity index values for all communities in this study were broadly similar (Table 5.2) some local differences among communities could be observed. In Fiji, the low sensitivity index observed for the communities of Ligau, Daku, Yaro, Namakala, Waiqanake, and Nabaka was due to households' reliance on non-fishery related occupations. Conversely the communities of Ligau, Daku and Yaro on Kia Island depended heavily on fishing as their main source of food and income. Reliance on agricultural activities in these three communities in Fiji was minimal due to the small size and steep-sloped topography of the island and, therefore, the scarcity of arable land (Jupiter *et al.,* 2012) — although this does not prevent households in these community from continuing small-scale farming on land that is available. The communities of Nabaka and Waiqanake in Fiji and Dunde in Solomon Islands had a high degree of dependence on reef resources (Figure 5.3a & b) despite being close to urban centres having access to good fertile land which could be used for farming. Key informant interviews in these communities revealed that most people leave school at an early stage to go fishing because it has been their main source of livelihood for years.

Households that are dependent on reef resources for income and food are likely more prone to be impacted by decreasing reef resources and coral bleaching (Allison *et al.,* 2009). However, Pacific Island communities and reefs are also highly vulnerable to other impacts of climate change such as sea level rise (Brookfield, 1989; Meehl, 1997; Burke *et al., 2*011; Pendleton *et al.*, 2016) and the predicted increase in the frequency and severity of tropical cyclones (Hay &

Mimura, 2006), which are the most destructive weather disturbance that affects communities in the Pacific region (Emanuel, 2003).

While detailed analysis of these longer-term climate-related threats are beyond the scope of this study, it is clear that a high degree of adaptive capacity will be required by populations of both countries over both the short and long term. The sustainable livelihoods framework (SLF) (Scoones, 1998; DFID, 1999) concept of livelihoods assets (i.e. human, natural, physical, natural, financial and social capital) was used in this study as a building block to assess the adaptive capacity of communities, which could help reduce vulnerability. Adaptive capacity index values were relatively similar for communities in Fiji and Solomon Islands; however individual analysis of the adaptive capacity indicators showed that communities in Fiji and Solomon islands differed significantly in scores for some indicators such as infrastructure, MSL and level of trust, which could influence the communities' capacity to cope and adapt to stresses thus affecting vulnerability. This supports findings of Adger (2003) and Smit & Wandel (2006) that households within a community are not equally vulnerable as they may be differentially affected by climate change based on their level of adaptive capacity. The following sections discuss the results obtained for each of the five livelihoods assets in more detail.

5.3.2 Social assets

Social capital, which was measured by level of trust and whether a household belong to a social committee (see Table 3.6 in Chapter 3), helps households cope with stress. FGD participants in all communities in Fiji and Solomon Islands stated that they trust and have good social relationship with immediate family members. Levels of trust in other households and organizations with a presence in the community varied between countries and among communities.

Trust among people and households and people's trust of community organizations, NGOs and government strengthens social cohesion and underpins participation by households and communities in community development projects. This was evident in the recent cyclone in Fiji, where everyone in the affected communities of Tuatua, Nakodu and Natokalau listened to the chiefs and elders and worked together in the rehabilitation of their community. By contrast residents of Kindu, Dunde, Lodumaho and Kekehe in the Solomon Islands displayed a low level of trust in village leaders and other people in the village. During the focus group interviews from Dunde, Kekehe and Lodumaho, respondents said that they did not trust anyone and they even did not know who the chief in their community was. This lack of trust seemed likely related to wider social problems in these three communities; for examples the same FGD participants in Dunde, Kekehe and Lodumaho mentioned that there were increased numbers of youths smoking and the consumption of alcohol was high.

Social groups, institutions and organizations can act as culturally and historically specific mediators between individuals and societal levels (Glaser & Glaeser, 2011). In particular, the development of trust within a community and between communities and other stakeholders is crucial for successful adoption and implementation of adaptation measures (Armitage *et al.*, 2009). A study of agricultural systems in Kenya showed that lack of trust was a barrier to the flow of knowledge in the adoption of new agricultural technologies proposed by government and farmers (Eidt *et al.*, 2012). Similarly, lack of trust has been identified as a critical issue to overcome in order to promote fruitful cooperation between Pacific Island countries and western science (Cvitanovic *et al.,* 2016). The inability to exchange knowledge between scientists and local communities could negate the engagement of communities with scientists and NGOs.

Conversely trust within communities facilitates self-organization and promotes participation in community projects and meetings. Moreover, trust in governance institutions at the local level could be one major factor in determining whether people and households comply with marine conservation programs (Matera, 2016). Thus participation of communities in decision making is a key factor in local-level resilience to environmental stressors (Tomkins and Adger, 2004). For example, trust increases the capacity of communities to organize when environmental stresses occur and to draw on outside resources (Cinner *et al.,* 2009). This could include requesting the assistance and help of other households; however, dependence on other households could also increase households' vulnerability if there are no other local opportunities, economic linkages and community development available (Walker *et al.,* 2004).

Level of trust in NGOs and government in Fiji were high, likely a result of their continual support at the community level. All the communities in Fiji are active members of the Fiji Locally Managed Marine Areas Network (FLMMA) which is a non-profit association of resource conservation NGOs, government departments, academic institutions and over 400 communities that works to promote the sustainable use of marine resources in Fiji (https://www.fijilmma.org/about-us). In the communities of Muaivusu, Nabaka, Namakala and Waiqanake, perceptions of the current government were highly favourable because it had recently provided them with tap water, which other governments had failed to do for decades.

In Solomon Islands, where trust in NGOs is lower, focus group discussions from Solomon Islands revealed that most communities had not been visited by government officials for months and were visited occasionally by external researchers and NGOs. The only NGOs actively working with communities were the Tetepare Descendants Association (TDA), which had a presence in Vanikuva, Rano and Bangopigo, and the Roviana Conservation Foundation that works with the community of Nusa Hope. The presence of the TDA could be the reason why levels of trust in government and NGOs were relatively high in Bangopigo, Vanikuva and Rano, compared to other communities in Solomon Islands.

The active involvement of NGOs and government in Fijian communities in natural resource management could reduce vulnerability and increase the capacity of communities to cope with

and adapt to social and environmental change (Berkes & Seixas, 2005). Conversely, the lack of trust and institutional linkage observed for communities in Solomon Islands could negatively affect their ability and capacity to adapt (Adger *et al.*, 2005). It was notable that, although the level of trust in community leaders and NGOs in communities in Solomon Islands was low, trust in religious leaders was high. Church leaders have been referred to as "gatekeepers" in communities and can potentially play a role in promoting individual and collective action towards building adaptive capacity (Adler, 2001; Cvitanovic *et al.,* 2016). But opposition or disinterest on the part of church leaders can also lead to the downfall of conservation programs, as observed in Roviana in Solomon Islands, where a change in church leadership negatively affected collective action and social capital, with negative consequences for marine management (Rohe *et al.* 2017).

In both countries, most respondents said they attended community meetings but while 52% of respondents in Fiji said they spoke in community meetings, only 26% did do in Solomon Islands. The degree of participation of households in meetings in both countries depends on their status within the community and people's cultural and traditional identity in the community. For example, people in Fiji are born into their role in the community (e.g. as fisherman, spokesman, chief, or warrior) and these identities cannot be changed. Respect for one another is also based on how people are related. In both countries, respect is derived from the kinship system and is based on gender, age and social distance. Social distance is a measure of how closely related a person is to someone else in the community. The older the person is, the more respect they command regardless of gender or social rank. For example in Fiji, people within a community are closely related to one another and relationships can prohibit participation in meetings. Women in both countries played a more passive role in decision making in the past but this is changing in some communities where women are allowed to voice their views during community meetings. For example in Fiji, communities are often encouraged by NGOs and government to have a women's representative at marine management and awareness workshops.

The degree of participation was also affected by local circumstances. In Fiji, participation by households in Ligau, Daku and Yaro in decision making was relatively high, possibly due to their involvement in the recent installation by the government of a desalination chamber on of Kia Island to help combat the water scarcity faced by households there. Another NGO (Community Centred Conservation) is also actively working with these three communities.

The low percentage of participants actively participating in meetings in Solomon Islands could negatively impact of adaptive capacity in the communities. However, in both countries, while most meetings were attended by most heads of households, decisions were made by just a few people, often the elders. In most communities in Fiji, most decisions are made by the chief of the community and head of clans; while in Solomon Islands decisions are made by the council of elders and chief of the community. Decisions in these meetings could include the establishment of a *tabu* area and other rules on fishing practices. Low levels of participation in decision could affect the effectiveness of these measures, since multiple studies report that those that do not

participate in decision making are less prepared to adapt to change and comply with decisions that are made, in part because decisions that are taken are less likely to take households' interests into account (Reed, 2008; Coulthard, 2011; Cinner *et al.,* 2015; Cvitanovic *et al.,* 2015). Thus lack of participation by households in decision making is likely to increase their vulnerability by decreasing adaptive capacity.

5.3.3 Physical assets

The lack of access to infrastructure such as hospitals, health clinic, sanitation, public transport and markets in the remote communities of Fiji and Solomon Islands is likely to affect their capacity to cope with and adapt to environmental changes. Results from Solomon Islands resonate with other studies that the most vulnerable households and communities are usually poor and lack key infrastructure (Paavola, 2008; Cinner *et al.,* 2009*;* Islam *et al.,* 2014). In the remote communities of Bangopigo Rano, Vanikuva and Nusa Hope in Solomon Islands, most houses were thatched, with an absence of toilets, and very few material items were present in the households. In Fiji, the remote communities of Yaro, Daku and Ligau on Kia Island also lacked key infrastructure but houses were constructed from concrete, timber or tin and people possessed more material items. The lack of infrastructure such as treated piped water and proper toilets could increase vulnerability of communities in Fiji and Solomon Islands. A recent study in Ahus showed that the use of the sea as toilet can increase algal blooms and thus could lead to ciguatera fish poisoning (Ford *et al.,* 2017). Health education awareness programs should be conducted in communities to facilitate the construction of toilets in order to avoid such threats.

Communities poor in monetary terms could be highly vulnerable due to their high exposure to certain natural hazards, health-related or economic shocks (Allison *et al.*, 2006). The covariant nature of natural hazards, health (diseases) and economic shocks could prolong recovery and impede coping and adaptation by poor households and communities, thereby exacerbating their poverty (Barrett, 2005; Barrett & McPeak, 2005; Barrett & Carter, 2006). Communities considered poor based on material assets and infrastructure such as Bangopigo, Vanikuva, Rano, Nusa Hope, and Raromana in Solomon Islands might be expected to cope worse with stresses than more affluent communities.

However, an alternative view is that these communities could cope with and adapt to stresses better than communities which have more material assets and access to infrastructure. For example, possession of more 'modern' houses can potentially increase vulnerability, since rebuilding them is more difficult compared to traditional houses. A category 5 cyclone that struck Fiji in February 2016 (discussed in more detail in Chapter 6) destroyed more than 80% of the houses in Nakodu and Tuatua, two communities identified as relatively wealthy in this study based on the material assets of households, where houses were either concrete or wooden, with metal roofs. The impact of a category 5 cyclone in the remote communities in Solomon Islands could be less disastrous, compared to Fiji, since households in Solomon Islands have fewer

assets and houses can be easily rebuilt from locally available materials. Similarly, although access to land and agriculture increases adaptive capacity in normal circumstances, the cyclone in Fiji exposed communities who depended heavily on agriculture to another dimension of vulnerability. This shows the context dependence of vulnerability.

It is important to understand that for people in the communities, a 'wealthy' household is not solely defined based on possession of material items. Moreover the most vulnerable communities are not necessarily the poorest (McCulloch & Calandrino, 2003; Béné, 2009), when 'wealth' is defined in material terms. In a study in Kenya, poorer households were found to have higher occupational diversity and more participation in decision making (Cinner *et al.,* 2010), which increased their capacity to cope with and adapt to environmental stresses. Entitlement theory suggests that access to and command over natural resources rather than their availability is instrumental in determining poverty of households and communities that depend on these resources (Leach *et al.*, 1999). From this perspective, based on the results of this study, the communities of Rano, Bangopigo and Vanikuva in Solomon Islands have good social networks and access to land, which could enhance their capacity to adapt or cope with stress.

While other indicators of material wealth contribute indirectly to vulnerability, fishing gears have direct impact due to their effects of fisheries resources. Handline was the fishing gear most extensively used in Fiji and Solomon Islands. Households used other fishing gear such as gillnets, spearguns, trawling, hand spear and Hawaiian sling. This wide range of gear offers increased ability to catch fish for local communities; however it could also inflict more pressure on reef resources. The use of gillnets, spears and night diving have been shown to directly reduce reef resources (Cinner & Pollnac, 2004; Dulvy *et al.*, 2004; Hamilton *et al.*, 2012; McClanahan & Mangi, 2004). For example, a study by Mangi & Roberts (2006) evaluating the impacts of artisanal fishing gear on Kenya's coral reef ecosystems found that spears, gillnets and beach sein nets caused the most physical damage to corals. In this study FGD participants and KIs reported that night diving and night fishing with the use of gillnets have contributed considerably to decreasing reef resources. Gillnets in Fiji and Solomon Islands catch a diversity of fish species of different sizes, mainly for sale but with some fish kept for consumption. By contrast, spear guns are usually used selectively, targeting specific fish species that are bigger and better marketable (Hamilton *et al.,* 2012; Jupiter *et al.,* 2012). This was supported by findings from discussions with fishermen during FGDs in Fiji and Solomon Islands who stated that spreargun fishers targeted big size fish such as parrotfish, surgeon fish and trevally, among others. However, when used at night, spearguns have been found to be a contributing factor to decrease in the abundance of fish (Hamilton *et al.,* 2012). The need to manage fishing gears that target specific fish groups is crucial in the management of reef resources.

5.3.4 Financial assets

Most household respondents reported that credit was mostly obtained from local shops and family members and that loans were normally paid back within 2 weeks. Studies in African coastal and agricultural communities have suggested credit facilities such as microfinance could increase adaptive capacity (Mertz *et al.,*2009; Kuponiyi *et al.,* 2010*;* Cinner *et al.,* 2015; Bouroncle *et al.,* 2016). However I consider it is more likely that increased access to credit would increase pressure on households and reef resources in communities in Fiji and Solomon Islands that depend on fishing as their main source of income. It was found in Kenya that middlemen could offer credit based on trust to fishers but this was also found to hinder the diversification of livelihoods by fishers and lead to high fishing pressure because of debt (Crona *et al.,* 2010). Thus a vicious circle arises, with positive feedback between increasing income poverty and declining fishery resources, unless fishers seek out alternative sources of livelihood before asking for credit. For example, it was observed on Kia Island in Fiji that the presence of a middleman on the island had forced communities to fish day and night and there was no restriction and monitoring on the amount and size of fish bought by the middleman.

Direct conversation with respondents during household interviews, FGDs and KIIs in both countries revealed that households were reluctant to take loans from financial institutions, fearing hardships during loan repayment. The livelihood vulnerability of remote communities in Solomon Islands could be reduced if there were markets available where produce (agricultural and fisheries) could be sold. However, new demand from local and global markets has been shown to result in rapid development and overexploitation of fisheries in remote areas, leading to the collapse of stocks, for example of ornamental fish and sea urchins (Scales *et al.,* 2005; Berkes *et al.,* 2006). Thus increasingly globalized fish markets can create new vulnerabilities in communities, compounding environmental threats (Daw *et al.,* 2009). Although the availability of markets could improve livelihoods in remote communities in Fiji and Solomon Islands, measures should be taken to prevent the overexploitation of reef resources, with explicit recognition of the need for high trade-offs between development objectives and the need to conserve natural resources.

5.3.5 Natural assets

Reef fisheries and land for agriculture are the most important natural assets in both countries. In most communities fishing is preferred to agriculture as a source of livelihood, as discussed below. However, fishing is inherently a high risk livelihood activity "due to the fugitive nature of the resource, the hostile environment of the seas and the perishability of the product" (MRAG, 2011:3). Moreover reef resources are declining in many communities and highly vulnerable to future climate change in both countries. Thus, reef resources should not be the only source of livelihood for households where other alternatives are available.

Communities in Solomon Islands and Fiji have access to good land for farming. Communities in Nakodu, Tuatua and Natokalau in Fiji rely on the sale of farm produce (especially *kava* and taro) as their main source of livelihoods. Respondents from FGDs and household interviews there said that construction of their houses was funded from the sale of *kava*. *Taro*, which is sold by most households in Tuatua and Nakodu, has become their main source of livelihood recently due to access to an international market. However, the length of time for these crops to mature ranges from 6-8 months for taro and 3-5 years for kava. For this reason, some household respondents in Fiji, in communities such as Nabaka, Muaivusu, Waiqanake and Namakala, preferred fishing because it brought in money every day. In these communities, land is available with potential for commercial agriculture, but households' farm for subsistence use only.

In Solomon Islands, most households engage in farming. Similar to Fiji, communities in Solomon Islands prefer fishing to farming as their main source of income, but the extent to which this is feasible depends on their access to fishing grounds and availability of markets. Access to markets is also a problem for agricultural producers. Households in the remote communities of Vanikuva, Bangopigo, Rano, Nusa Hope and Raromana sell their farm produce at the markets in Muda or Gizo or within the village. Due to difficult access to transportation, producers only travel to the market once a week to sell produce. Improvement in infrastructure is thus vital to facilitate the marketing of natural resources. Similar to reef resources, the productivity of agricultural land is affected by climate change. Respondents from Fiji and Solomon Islands reported that climate change has influenced the times of planting certain crops such as taro, sweet potato and vegetables because of changing weather patterns. Similarly, farmers in Africa who told researchers that they had changed the timing of farming activities due to climate change (Fosu-Mensah *et al.*, 2012; Amos *et al.,* 2015).

Extensive research has shown that, when undertaken by local communities, both fishing and farming are highly sensitive to climate change and mostly undertaken with limited physical infrastructure (Challinor *et al.,* 2007; Kuponiyi *et al.*, 2010; Schlenker & Lobell, 2010; Badjeck *et al.,* 2010; Cinner *et al*., 2012; Hernández-Delgado, 2015). The vulnerability of households and communities depends on how well they respond to these climatic changes. Farmers need accurate information from government and expert stakeholders on weather patterns and crops that could be planted by households if certain climatic changes persist. Management of reef resources can help mitigate the effects of climate change on reefs, at least in the short term. In the longer-term the ability of households to engage in alterative livelihood occupations will become increasingly important as reef resources decrease as a result of climate change and anthropogenic factors.

5.3.6 Human assets

The ability of communities to perceive the cause of ecosystem degradation is vital to inform the choice of adaptive responses. If households are not able to perceive and comprehend the connections between human activities and climate change on one hand, and the condition of the

resources they depend on the other, willingness to participate in resource management alternatives will be limited (Cinner *et al.*, 2010).

More than 80% and 92% of households in Fiji and Solomon Islands, respectively, could identify causes of reef resources decrease that were directly linked to human activities. However, results from this study (Fig. 5.2) showed that only few respondents in Fiji and Solomon Islands perceived climate change as a cause for declining reef resources. Most of the respondents have lived in their communities for more than 20 years or most of their lives and during this time they have undoubtedly witnessed changes in reef resources and climate change-related effects. However, relating the loss of reef resources to effects of climate change requires knowledge and understanding of the climate dynamics and processes that can impact reef resources. During my interviews, it became clear that people understood climate change as changes in weather patterns, but were ignorant of the impacts of these changes on the marine environment. An exception was in the communities of Muaivusu and Nabaka in Fiji, where workshops on marine resource management conducted in these communities had apparently contributed to their local people's awareness of climate change.

Perceptions of climate change reported in this study could be influenced by gender and the level of education of respondents. The knowledge of climate change increases with education (Nzeadibe *et al.,* 2012). Studies have shown that women are more likely than men to view environmental stresses as hazardous (Fothergill, 1996) and are generally more vulnerable to climate change (Dankelman, 2002). In this study most respondents (67%) were male and, while more than 90% of respondents from Fiji and Solomon Islands had some formal education (primary and secondary), only 6% had attained tertiary education. The high proportion of male respondents in the household surveys and low levels of education could be reasons why few households perceived climate change and pollution as major causes of the decrease in reef resources.

Adger *et al.* (2004´) and Blankespoor *et al.* (2010) hypothesized that educational attainment can improve people's ability to cope with disasters. This was confirmed by a study on climate change, adaptation and formal education in El Salvador and Brazil (Wamsler *et al.* 2012), which found that improving the access to and quality of formal education can increase people's adaptive capacity. Increasing the education level of people in communities should thus be a priority in efforts to increase people's capacity to cope with and adapt to climate related factors that affect livelihoods in Fiji and Solomon Islands.

Specifically, in Fiji and Solomon Islands, more efforts are needed to inform communities about external factors related to climate issues such as global warming, coral bleaching, and natural disasters, and their impacts on natural resources. Advice and education is also needed on how communities can cope with and react to these threats, for example on the benefits of *tabu* areas through spillover of fish biomass from closed areas (Roberts *et al.*, 2001; Stobart *et al.,* 2009) and increased profits and incomes (McClanahan 2010; Jupiter *et al.,* 2012). Education is also

vital to increase the range of livelihoods options in the communities since, as noted above, the flexibility and ability of households to change occupations could help minimize loses brought by climate change on reef resources (Cinner *et al.*, 2013; Cinner *et al.*, 2018). Most households in Solomon Islands and few households in Fiji are already engaged in informal economic activities, in addition to farming and fishing, although there fewer opportunities to change occupations in Fiji than in the Solomon Islands. Alternatives that offer occupations that can sustain the livelihoods of households are crucial and this will be discussed further in Chapter 6.

5.4 Outlook: fostering adaptive capacity in the context of climate change

The vulnerability of households and communities to climate-related events that might occur in the future is likely related to their existing coping capacity over the short term and their ability to pursue long-term adaptation strategies (Brooks *et al.,* 2005).

The results of this study focus on the current situation and highlight the highly context-related nature of vulnerability. Exposure, sensitivity and adaptive capacity influenced the vulnerability of communities in different ways and those that were most exposed were not necessarily the most sensitive or least able to cope with stresses. It was notable that communities in Fiji and Solomon Islands that were identified as vulnerable based on specific adaptive capacity indicators had better adaptive capacity scores for other indicators. For example in Fiji, communities on Kia Island (Daku, Ligau and Yaro) were found to be highly vulnerable to decreasing marine resources and coral reef bleaching. Based on the results of this study, factors contributing to the vulnerability of these three communities were high exposure and low scores for adaptive capacity indicators such as occupational multiplicity, occupational mobility, infrastructure, access to credit and material style of life. On the other hand these three communities in Fiji scored well for other aspects of adaptive capacity, such as trust, involvement in decision making, gear diversity, and human agency. In Solomon Islands, where all communities were found to be vulnerable with relatively high levels of exposure and a medium level of sensitivity compared to Fiji, the communities were grouped into two categories based on the adaptive capacity indicators (Fig. 5.5). Communities of Dunde, Kindu, Lodumaho and Kekehe had high adaptive capacity based on infrastructure, material style of life, and occupational mobility, while Raromana, Nusa Hope, Vanikuva, Bangopigo and Rano had high scores for a different set of adaptive capacity indicators, i.e. financial capital, trust, human agency and access to land. Depending on context, the vulnerability of households in the study communities was also observed to be increased by their high dependence on agriculture.

Thus the vulnerability of households in communities was heavily dependent on the type of environmental stress they were exposed to, their sensitivity and the livelihood assets that could be affected by or drawn on to cope with the stress. This is important because households' adaptation and coping strategies are often based on past experience of stresses. Brooks *et al.*

(2005) found that countries that were frequently exposed to severe climate extremes were more likely to be prepared for and less vulnerable to recurrent climate stresses. Schwarz *et al.* (2011) report that more than 50% of respondents in the Solomon Islands strongly agreed that they had learned from past shocks and were in a better position to cope with future events.

The development of livelihoods critically depends upon the goods and services provided by natural resources and on the capacity of resource users (Dorward *et al.*, 2003). Barnett (2001) argued that Pacific Island societies have historically possessed large amounts of social and natural capital, enabling the development of a range of practices that has made them resilient to climate extremes and endowed them with a relatively high capacity to adapt and react to these events. However, increased variation and unpredictability in the frequency and intensity of stresses could limit the capability of households to adapt and cope. It has also been hypothesized that deeper engagement in a cash economy weakens social networks because of the shift from the idea of sharing to the purpose of selling (Lauer *et al.,* 2013). FGD participants in the study communities reported that social networks had been eroded through participation in the market economy. The social norm of working together as a community has been replaced by individualism, where each household is primarily concerned with pursuing its own interests. This erosion of social capital, combined with intensifying pressure natural capital represents a threat to traditional resilience of communities in Fiji and Solomon Islands. This agrees with finding of other studies that globalized trade, coastal developments and demographic changes have reduced the resilience of communities (Barnett, 2011; Schwarz *et al*., 2011).

Reef resources are the main source of livelihoods for remote communities in Fiji and Solomon Islands; therefore management of these resources should be paramount. The risks posed by human impacts and climate-related events such as coral bleaching to food security in the Pacific highlight that building adaptive capacity is the key priority in order to guarantee the long-term sustainability, health and safety of local communities (Barnnett & Campbell, 2010). Building adaptive capacity could lay the foundation for design and implementation of effective adaptation strategies to mitigate threats posed by environmental stress (Brooks *et al.*, 2005). This will require the existence of adaptive institutions that enhance learning in the context of change and uncertainty by fostering a willingness to learn from mistakes and engagement in collaborative decision-making (Folke *et al.,* 2003).

Understanding of the nature of the risks and the specific factors affecting the vulnerability of individual households and communities in different areas is important for success in developing adaptive capacity (Grothmann & Patt, 2005). Specifically, adaptation measures are more likely to be successful "when local communities have good perception of the risks and vulnerability of their settlements and livelihoods to climate change and have begun to employ local knowledge, skills and technology to find the best set of adaptation measures" (Amos *et al.,* 2015:889). Households in Fiji and Solomon Islands perceive that there is a decrease in reef resources and based on their understanding of its causes, are implementing adaptation measures, as discussed in Chapter 6. These should form the starting point for development of strategies to foster

adaptive capacity in the communities, with an emphasis on adaptive measures that encourage innovation in ideas, practices and management strategies (Armitage, 2005)..

The adaptive capacity of households and communities in Fiji and Solomon Islands can be thus enhanced over time through enabling changes in economic, social, political and institutional conditions. Results suggested that more involvement of government and NGOs in community level interventions as aimed at improving infrastructure, creating social capital, home improvements (in terms of sanitation, water systems and housing structure) could help to increase adaptive capacity of communities. However, the effects of climate-related events such as coral bleaching and cyclones, compounded to greater or lesser degree with ongoing anthropogenic impacts will inevitably increase the vulnerability of communities that depend on fishing for their livelihoods. To prepare for this likelihood, governments should provide credit specifically for the development of alternative climate-resilient livelihoods, in addition material aid to improve current livelihoods.

6 Chapter 6: Adaptation and Transformative Strengths of Communities and Households in Fiji and Solomon Islands

6.1 Introduction

The concept of adaptation has been used both explicitly and implicitly in the fields of social sciences , including political ecology (Sen, 1981; Walker, 2005) and studies of natural hazards (Blaikie *et al.*, 1994; Turner *et al.,* 2003; Blankespoor *et al.*, 2010; Metcalf *et al.*, 2014; Hobday *et al.,* 2016), entitlements and food security (Adger & Kelly, 1999; Adger, 2000; Cinner *et al.*, 2009; Daw *et al.,* 2012). The term adaptation was first applied to human systems by an anthropologist who used the term "cultural adaptation" to describe the adjustment of cultures in subsistence economies in relation to the natural environment (Butzer, 1989). In the social sciences, adaptation has been viewed as contributing to the success or survival of cultures (Smit & Wandel, 2006) and as cultural practices that permit a culture to survive (O'Brien & Holland, 1992). In the context of social-ecological systems, "adapting refers to the proactive planning of longer-term courses of action that lead to beneficial outcomes for social and ecological systems" (Bennett, *et al.*, 2015: 909).

In the context of stressors arising from global change, adaptation refers to "a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with manage or adjust to some changing conditions, stress, hazard, risk or opportunity" (Smit & Wandel, 2006: 282). There have been numerous other studies that have described and defined adaptation (Smit *et al.*, 2000; McCarthy *et al*, 2001; Brooks, 2003; IPCC, 2007). This study follows Brooks (2003:8) which defines adaptation as "adjustments in a system`s behavior and characteristics that enhance its ability to cope with external stress". This includes changes in social and environmental processes, perceptions of climate stresses, and practices that moderate or offset potential damages or take advantage of new opportunities that may arise which could reduce vulnerability (McCarthy *et al*., 2001).

It is commonly asserted that adaptation to climate-related risks is based on the level of economic development, where economically developed societies have greater access to technology and resources to invest in adaptation (Adger & Vincent, 2005). According to Adger and Vincent (2005), studies of traditional societies have demonstrated that adaptation in many senses depends on experience, knowledge and the degree of dependence on weather-sensitive resources. Moreover, the adaptation options that households and communities choose are often based on beliefs and perceptions that influence decision-making processes (Grothmann & Patt, 2005; O'Brien, Quinlan, & Ziervogel, 2009; Adger *et al.*, 2009; Schwarz *et al.*, 2011). In principle is possible to distinguish between to aspects of adaptation: 1) building adaptive capacity to increase the ability of individuals, households and communities to predict and adapt to changes; and 2) implementing adaptation decisions (Daw *et al.*, 2009). In practice, adaptation more often appears as a "continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life and that reflects existing social norms and processes" (Daw *et al.,* 2009:137).

Fishing as described in Chapter 4 is a way of life for most coastal communities in Fiji and Solomon Islands and a major source of food and income. Fisheries are under pressure from over-exploitation and climate-related disturbances, both of which threaten livelihoods of households in coastal communities. Numerous studies have found that, while fishers are aware of fluctuations in catch, they often do not understand the factors underlying short- long-term trends in stock abundance, such as overexploitation (van Densen, 2001; Scheffer *et al.*, 2005; Maynard *et al.*, 2010). In this study, fishers in Fiji and the Solomon Islands displayed an awareness of some of the factors leading to overexploitation of reef resources, but were not aware of the potential effects of climate change.

Fishers respond to decreasing catch and yield by increasing effort, changing fishing sites, changing gear, or exiting from the fishery if better options are available (McClanahan *et al.*, 2005; Cinner, *et al*, 2009; Daw *et al.,* 2012). Where fisheries are declining and fishers have access to alternative livelihoods, fishing effort has been found to fall (Cinner & Bodin, 2010). Alternatively, where alternative livelihoods are lacking in the local economy, fishing communities may be locked into dependence on the fishery (Cinner *et al.*, 2009; Ikiara & Odink, 2000). However, the ability and capacity of fishers to leave fisheries and adopt alternative livelihood options is not only linked to the availability of economic incentives but is also related to various cognitive, cultural and socio-economic factors (Grothmann & Patt, 2005; Maldonado & Moreno-Sanchez, 2014), many of which are strongly affected by local context (Pollnac *et al.*, 2001; Pita *et al.*, 2010; Daw *et al.,* 2012).. These may include age, education (Wamsler *et al.,* 2012), occupational diversity (Cinner & Bodin, 2010), wealth and traditions (Cinner *et al.*, 2009), all of which can directly influence decisions to stay or leave fishing.

Chapter 5 of this thesis examined the capacity of fishing households in coastal communities to adapt to or cope with decreasing reef resources caused by overfishing and coral bleaching. This chapter explores the different factors that facilitate or constrain adaptation by households and communities. Firstly it discusses adaptation strategies currently favoured by fisher households and widely adopted by coastal communities in Fiji and Solomon Islands in response to the decline in reef resources, namely the establishment of *tabu* areas. Secondly it further deliberates on the different factors that determine the ability of a household to exit a declining fishery. It identifies and assesses the socio-economic factors that might induce fishers, households and communities in Fiji and Solomon Islands to exit the artisanal fishery, and explores alternative livelihood options that are available to them if they decide to do so. While the first of these responses (improved management of the fishery) is an adjustment to stresses that involves only minor system modifications, the second response (leaving the fishery) has the potential to fundamentally alter the system itself, shifting the system into a new state (Kasperson *et al.*, 2005). It goes beyond adaptation towards what is referred to a "transformation" in social-ecological systems literature (Barnes *et al.*, 2017). Finally the chapter considers the lessons to be learned from actions by local people to cope with and adapt to an extreme climatic event that occurred in Fiji while field work for this study was being carried out and had a devastating effect

on livelihoods, i.e. tropical cyclone Winston, which struck Fiji on February 20, 2016. This experience highlights that what constitutes "adaptation" to one set of circumstance may increase vulnerability to different threats. Thus building the capacity to adapt should be understood, not as the adoption of a particular strategy, but as the development of flexibility to change strategies, ability to organize and act collectively, learning to recognize and respond to change, and agency to determine whether or not to change (Cinner *et al*., 2018).

6.2 Results

6.2.1 Fishers' responses to declines in catches

The establishment of *tabu* areas was perceived by households in both countries as the best tool which could increase the abundance of fish. Other responses identified in both countries included stopping overharvesting, stopping night diving and planting of corals (Table 6.1). The PCA performed on respondents' responses regarding their perception of what could increase the number of fish in the sea retained the first 3 principal components for Fiji and Solomon Islands based on the scree plot (Appendix Table A 6a & 6b). From the 10 mentioned responses from Fiji, 9 responses were retained (Table 6.1). In the Solomon Islands, 8 were retained from the 21 responses (Table 6.1). These explained 41% and 23% of the variation among households based on responses from Fiji and Solomon Islands respectively.

Table 6.1: Respondents' perception of what could increase the number of fish in the sea.

Country	What can increase the number of fish?	Respondents (%)
Fiji	***Tabu* areas**	**78.5**
	Stop traditional fishing	7.3
	Stop polluting the shore	4.1
	Stop night dive	2.8
	Plant coral	2.0
	Stop overharvesting	1.2
	Education and Awareness	0.8
	Stop catching undersize fish	0.8
	Stop poachers	0.4
Solomon Is	***Tabu* areas**	**55.4**
	Fish less	13.1
	Reduce use of nets	6.9
	Stop overharvesting	5.2
	Plant corals	4.2
	Stop night dive	4.2
	Fish for pelagic	0.7
	Stop harvesting sea cucumbers	1.0

6.2.2 Responses to anticipated future declines in catches

6.2.2.1 Willingness to leave the fishery

The majority of fishers from Fiji and Solomon Islands stated that they would adapt their fishing practice if catch decreased (Fig. 6.1). The proportion of fishers that would adapt their fishing methods when faced with a hypothetical 20% decrease in catch was 88% in Fiji and 67% in Solomon Islands, while only few respondents would exit fisheries under this scenario. A chi-square test on the distribution show significant difference in responses between countries at 20% (x^2=28.055, df=2, p=0.000). The fishers' response to a hypothetical 50% decrease in catch also differed between the two countries. In Fiji, 67% of the fishers said that they would adapt while 26% said they would exit the fishery. By contrast, in Solomon Islands, 49% of fishers claimed that they would exit the fishery compared to 49% who said that they would adapt their fishing practice (Fig. 6.2). A chi-square test on the distribution show significant difference in responses between countries at 50% (x^2=23.710, df=2, p=0.000). In both countries, very few households mentioned continuing fishing as before as an option under this scenario. There were also significant differences in responses to the hypothetical decrease of 20% and 50% within country. Chi-squares test on the distribution show significant difference in responses at 20% (Fiji: x^2=87.444, df=45, p=0.000; Solomon Islands x^2=116.932, df=40, p=0.000) and at 50% (Fiji: x^2=107.931, df=45, p=0.000; Solomon Islands: x^2=100.296, df=40, p=0.000).

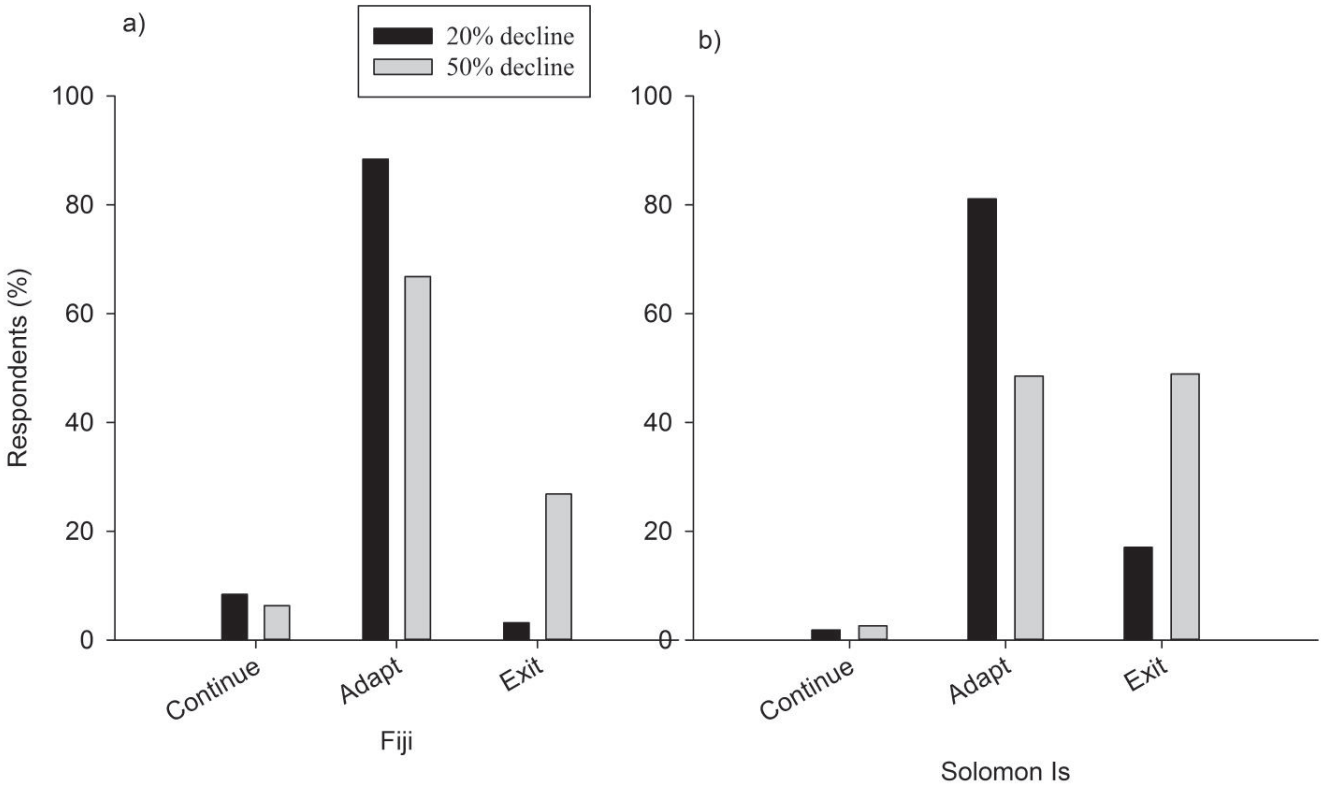


Figure 6.1: Fishers' responses to two hypothetical scenarios of declining catch rates (20% and 50%) for Fiji and Solomon Islands. Fishers' responses include continue fishing (continue), exit fishery (exit) and adapting fishing practices (adapt). The adapt category includes reduce effort, fish harder, change gear and change location.

6.2.2.2 Classification tree analysis

The classification tree analysis constructed from the data showed that 'community' was the most important factor in driving differences in the readiness to exit fisheries for households (Fig. 6.2). The group of communities less prone to quit fishing and opting to stay formed one group (Fig. 6.2), which included only Dunde in Solomon Islands and eight out of ten communities in Fiji, i.e. Muaivusu, Nabaka, Waiqanake, Namakala, Daku, Ligau, Yaro, and Natokalau. Material style of life (MSL) appeared to be the most important factor in the decision of households in Group 1 to leave the fishery, with higher MSL leading to an increased willingness to quit. Other variables such as poor catch and age appeared lower in the tree for communities in this group. The other ten communities that would exit formed Group 2 (Fig. 6.2), consisting of two communities in Fiji, i.e. Tuatua and Nakodu, and eight of the 9 communities in Solomon Islands, i.e. Kekehe, Kindu, Lodumaho, Nusa Hope, Raromana, Rano, Bangopigo and Vanikuva. The classification tree analysis identified the amount of fish caught during a normal day (normal catch) as the factor that explained most of the variability in fishing households' willingness to exit fishery, where lower catches were associated with a higher readiness to quit. Other factors such as age,

infrastructure, fishing gear, fishing experience and occupation multiplicity resulted in splits lower down the classification tree.

When the effect of community was removed from the tree model, 'fishing as the main source of food and income' was the most important factor driving differences in the readiness of fishing households to exit a declining fishery. Country-specific factors determined the decision to stay in fisheries, and poor catch was the determining factor for those that would consider exiting the fishery.

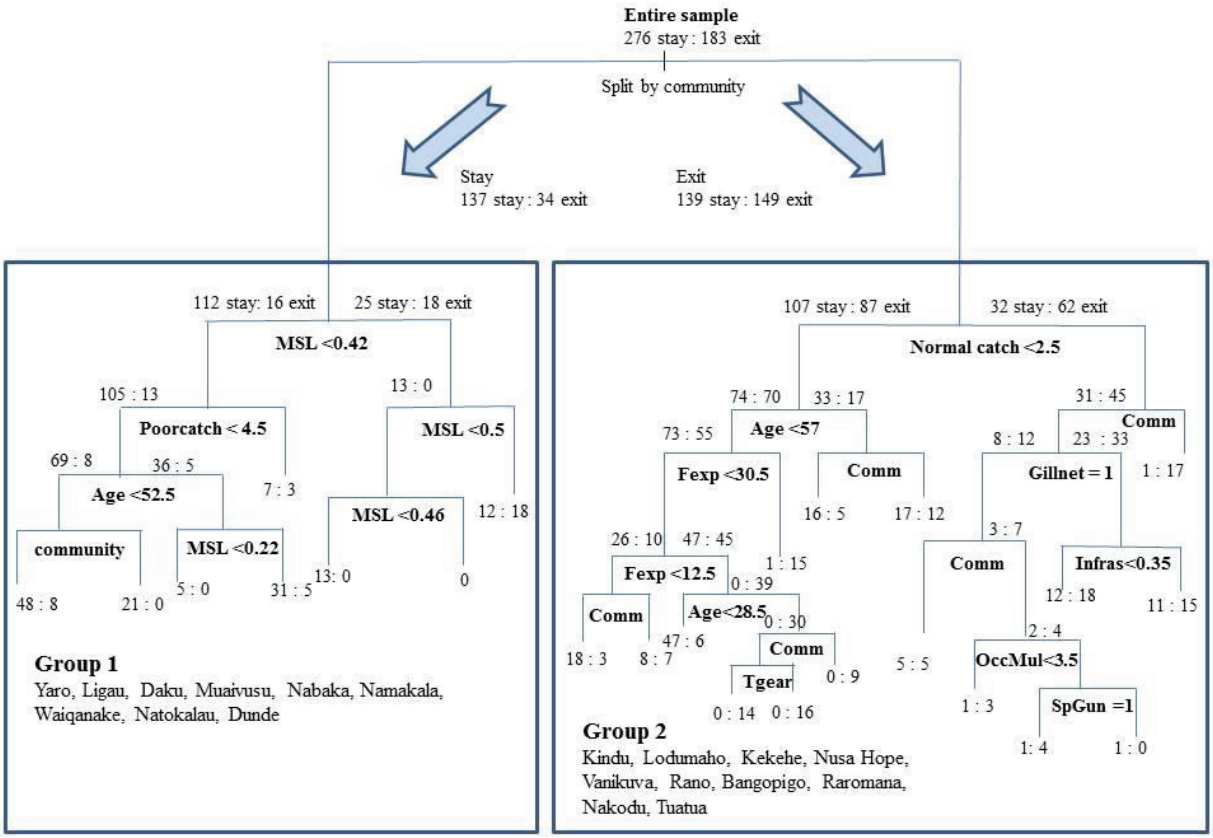


Figure 6.2: Classification-tree analysis assessing the decision to stay (left panel) or exit (right panel) fisheries in response to the hypothetical 50% decline in catch. Group 1 and 2 are the communities. On the 459 fishing households in Fiji and Solomon Islands, splits are based on the variables shown in Table 3.7.

6.2.2.3 Factors determining households choice to exit fishery

The pairwise evaluation of the p-values of the Spearman rank correlations between the numeric independent variables is shown in Table 6.2. This was done to check for pairwise correlation to avoid multicollinearity of the final regression model. MSL ranked high in explanatory power of

the variance in fishers' willingness to quit in the results of our tree model, and was thus retained for multiple regression. Since it significantly correlated with occupational diversity, age, infrastructure, and normal catch, these parameters were removed from the regression model. Normal catch, which ranked most important after community, was significantly correlated with total gear, poor catch, good catch and fish sold, which accordingly were removed from the multiple regression as well. Fishing experience was correlated with education, and since fishing experience appeared further up in the tree model; education was removed from the model.

Table 6.2: p-values of pairwise Spearman rank correlations of the numeric independent variables. p-values <0.05 are set in bold, values <0.001 in bold italic.

	MSL	Occupation multiplicity	Age	Fishing experience	Infrastructure	Education	Total gear	Poor catch	Normal catch	Good catch	Fish sold
MSL		**0.022644**	**0.015739**	0.991505	***0***	0.067145	0.712453	***4.13E-05***	**0.042075**	0.075246	0.592464
Occupation multiplicity	**0.022644**		0.056477	**0.021318**	***0***	0.060496	***0.008449***	0.614135	0.071738	0.05224	0.057142
Age	**0.015739**	0.056477		***0***	0.128898	***1.1E-08***	0.328163	0.384237	**0.032756**	0.152216	0.173187
Fishing experience	0.991505	**0.021318**	***0***		0.685098	***2.67E-06***	0.27091	0.592559	0.159307	0.237291	0.366801
Infrastructure	***0***	***0***	0.128898	0.685098		0.967078	0.992052	***0.000233***	***0.00954***	***0.002378***	0.496282
Education	0.067145	0.060496	***1.1E-08***	***2.67E-06***	0.967078		0.348971	0.684061	0.404811	0.39702	0.280259
Total gear	0.712453	***0.008449***	0.328163	0.27091	0.992052	0.348971		**0.019741**	***8.9E-05***	***9.29E-05***	0.629069
Poor catch	***4.13E-05***	0.614135	0.384237	0.592559	***0.000233***	0.684061	**0.019741**		***0***	***0***	**0.022598**
Normal catch	**0.042075**	0.071738	**0.032756**	0.159307	***0.00954***	0.404811	***8.9E-05***	***0***		***0***	***0.007313***
Good catch	0.075246	0.05224	0.152216	0.237291	***0.002378***	0.39702	***9.29E-05***	***0***	***0***		**0.0366**
Fish sold	0.592464	0.057142	0.173187	0.366801	0.496282	0.280259	0.629069	**0.022598**	***0.007313***	**0.0366**	

The final general linear model (GLM) confirms that community-specific factors (in particular Lodumaho ($p = 0.025$), and Kindu ($p = 0.012$), both with a high likelihood to choose to exit the fishery), played a significant role in explaining why an individual fisher would agree to abandon fishing. It further demonstrates a positive effect, i.e. increased willingness to exit the fishery, of use of speargun ($p = 0.009$), reduced catch obtained on a normal day ($p < 0.001$), and perception of fisheries ($p < 0.001$). Having fishery as first income and food source ($p < 0.001$) and involvement in trawl fishing ($p = 0.008$) is associated with a decrease in willingness to quit fishing.

6.2.2.4 Adaptation options for exiting households

Evaluating the responses from fishers in different communities on what they would do if they exit fisheries in response to a hypothetical 50% decrease in catch, 64% of the respondents in Fiji and Solomon Islands identified farming as their best alternative source of livelihood. The proportion of fishers that mentioned informal economic activity was 43% in Solomon Islands and 18% for Fiji (Fig. 6.3). These informal activities included small shops and canteens, sale of cigarettes and pastries such as buns and donuts, renting of fishing gear, sale of betel nut (only in Solomon Islands), sale of kava (only in Fiji) and sale of crops, carvings and mats. Household interviews showed that communities of Nakodu and Tuatua in Fiji sell husked coconuts to middlemen in Suva, who sell them at the local market. Communities of Yaro, Ligau and Daku on Kia Island in Fiji do not have good arable land on which they could plant crops, even for household consumption but households continue to farm despite poor soils. Salaried jobs were only available to households in communities closer to town. These in included, in Fiji, Waiqanake, Muaivusu, Nabaka and Namakala (close to Suva), and Natokalau (close to the PAFCO fish processing and canning plant); and, in Solomon Islands, Kekehe, Dunde, Lodumaho and Kindu (close to Munda town and the fish cannery). Copra was only mentioned by households in Solomon Islands, where it was an important part of the local economy in Bangopigo, Vanikuva and Rano:

> "Almost every household in [these three communities] owns a coconut plantation and this is our wealth. If you do not own a coconut plantation then you are poor. We sell copra to the agents in the village when we need money. If there is no money to buy our copra since the boats take weeks to come to the village, we use coconuts to pay for goods from the shop. E.g. 10 coconuts for a bar of soap" (B.A, Bangopigo, 16/04/2015)

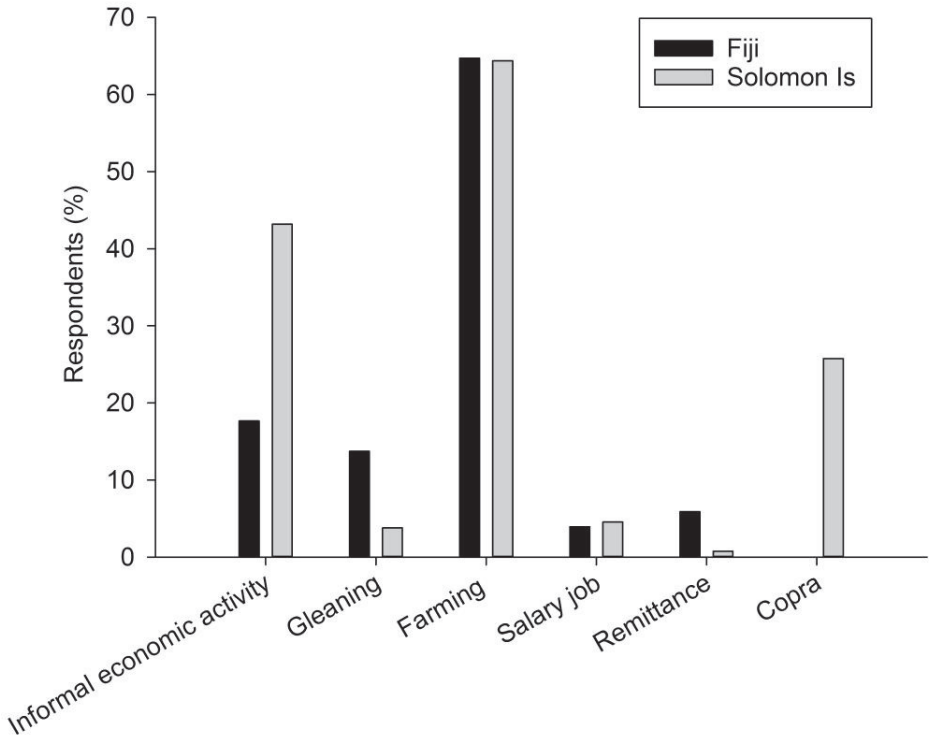


Figure 6.3: Different activities respondents stated they could be engaged in if they decided to stop fishing

6.2.3 Impact of cyclone Winston on livelihoods and adaptation measures by households in Tuatua, Nakodu and Natokalau, Fiji

6.2.3.1 General coping and adaptation measures

On February 20, 2016 a category 5 tropical cyclone Winston with sustained winds of up to 300km/hr struck Fiji (Esler, 2016). Its impact on households in the communities of Nakodu, Tuatua and Natokalau was devastating. The cyclone not only destroyed and damaged houses and infrastructure but also crops, which were the main source of livelihood for most households. Most houses and a large part of the infrastructure in Tuatua and Nakodu were destroyed by tidal waves which struck these communities at the height of the cyclone. This left households in a state that they had never experienced before. The experience highlights that, while farming was mentioned by most households in Fiji and Solomon Islands as a measure to adapt to decreasing reef resources, reliance on farming can lead to increased vulnerability with regard to other climate change-related threats.

More than half of the households interviewed in Natokalau and Nakodu stated that they needed to build stronger houses in order to cope with future cyclones (Fig. 6.4). The majority of respondents from Tuatua mentioned that the cyclone warning was not clear and there was no warning of the tidal wave. Respondents stated forcefully that a good evacuation centre needed to be built and their spiritual life with God needed to be strengthened. Few households believed that the relocation of their village could prevent the impact of tidal waves.

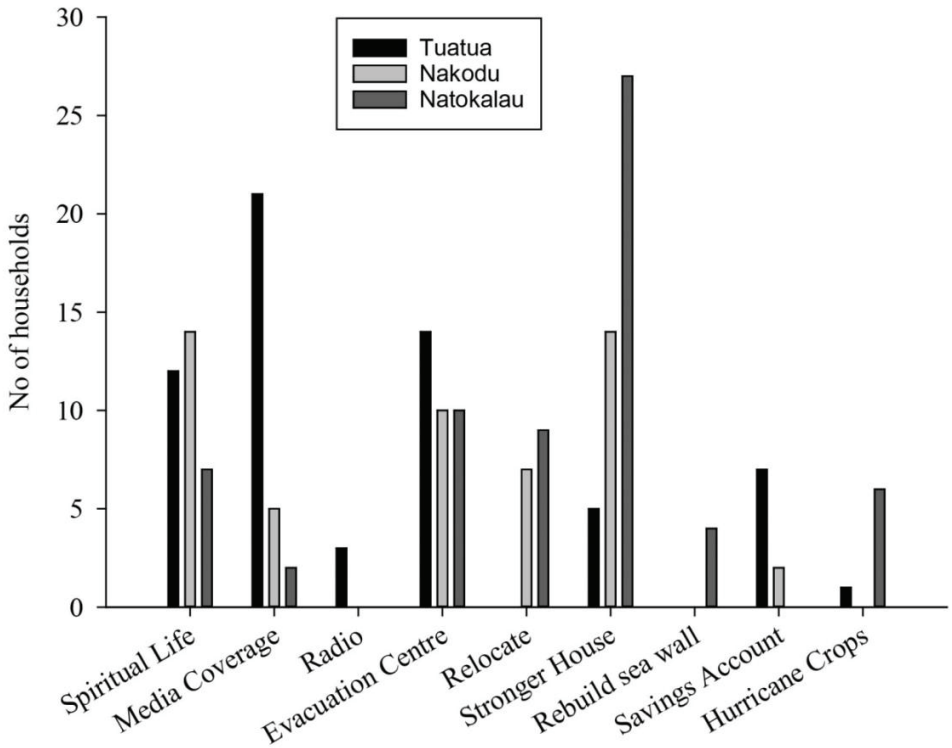


Figure 6.4: The different sources of strength that respondents said could help them cope with a future cyclone. The responses could be categorized into different sustainable livelihoods framework (SLF) assets: social assets (spiritual life, media coverage); physical assets (radio, evacuation centre, relocation, stronger house and rebuilt sea wall); financial assets (savings account); natural assets (planting hurricane crops such as sweet potatoes, yams, some species of taro).

6.2.3.2 Coping with Impact on Crops

The communities of Tuatua and Nakodu depended heavily on the sale of their crops such as *taro* and *kava* as their main source of livelihood and also produced coconuts and dried pandanus leaves (for making mats and artefacts). The cyclone destroyed almost all economically important

crops and food crops in Nakodu and Tuatua (Fig. 6.5a and b). Damage was less severe in Natokalau, where only half of crops were completely destroyed while other farms were only partly destroyed. The effects on households in Nakodu and Tuatua will be felt for a long time to come:

> "I am still lost and do not know what to do and where to start. I am still eating from food rations given by government. I have lost about 10,000[9] six months old taro plants and 6, 000 kava plants of which more than 3,000[10] were ready for harvest. I have also lost my truck. All is gone, house, crops, truck, and life will never be the same again for me." (K.N, Tuatua, 05/07/2016)

Recovery is proceeding slowly. Access to farms after the cyclone was difficult due to trees that fell during the cyclone. Cassava had been widely replanted by most households two months after the cyclone (Fig. 6.5c). However, other crops such as taro, vegetables, sweet potato and *kava* were not planted until four months after the cyclone due to lack of seedlings. Communities of Tuatua and Nakodu have been affected by the presence of caterpillars which ate the leaves of crops that had been replanted especially taro, sweet potato, kava and vegetables (Appendix F). The government of Fiji provided each household in the three communities with food rations soon after the cyclone. These food rations included rice, sugar, flour, salt, canned fish, canned meat, and noodles, amongst other essential, mostly processed foods. However most of the households reported that the food ration would only last the next two months (from the date of the interviews), since government had decided to stop the supply.

Despite these problems, most respondents from Nakodu and Natokalau were optimistic that the coping strategy used in replanting crops had succeeded (Fig. 6.5d). Respondents in Tuatua said that they would only know if the replanting of crops had been successful when they harvest them.

[9] 10,000 taro plants when mature after 7 months could be sold for $1USD a kilogram. The amount the farmer could earn would be close to $4,000USD if all taro plants had survived

[10] 3,000 kava plants could be sold for $50USD per plant. The amount the farmer could have received was $7500USD or even more. The farmer lost $11,500USD worth of crops that were ready to be harvested and this amount equates to approximately $23,000FJD.

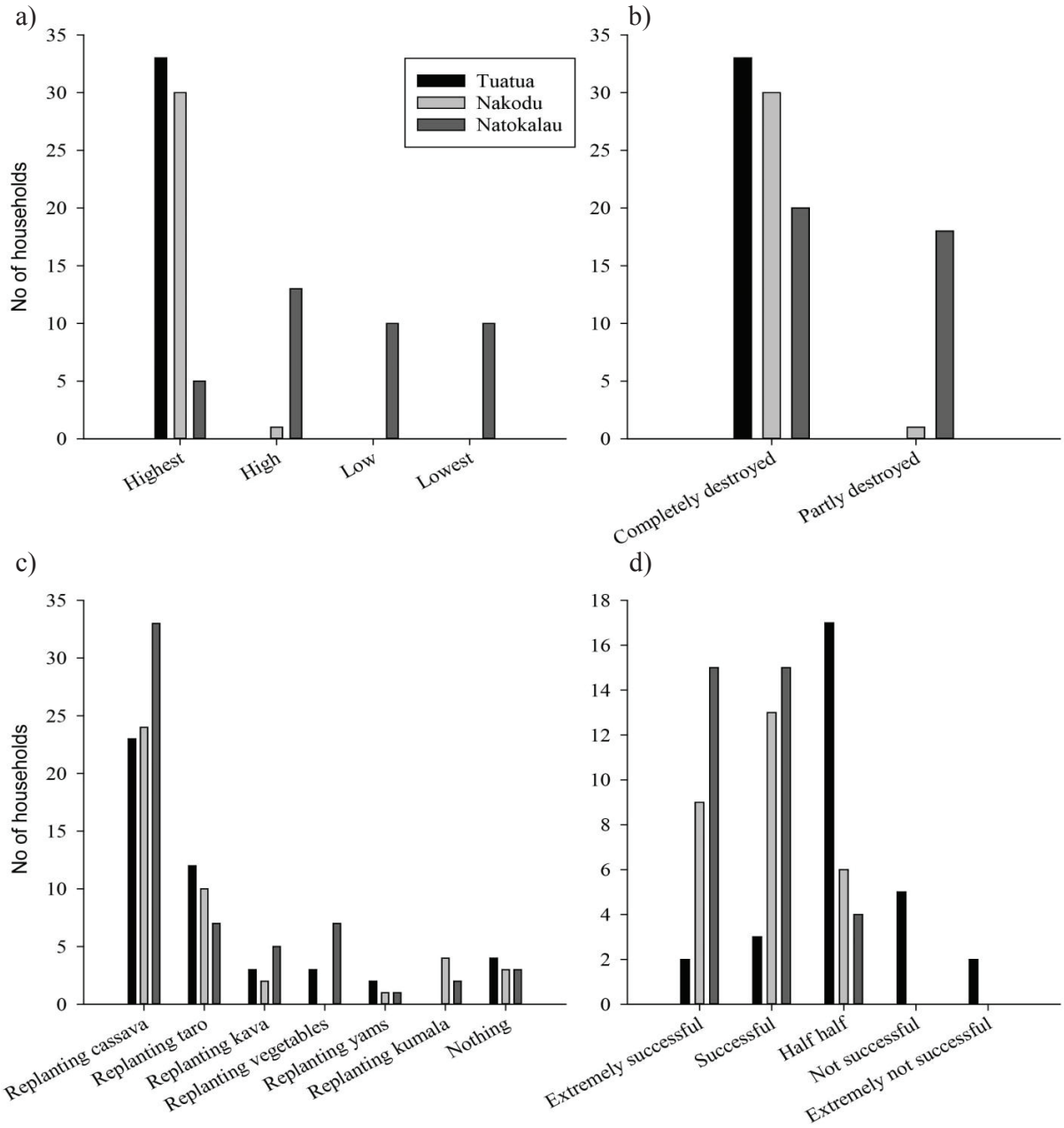


Figure 6.5: a) Impact of crop damage on household economy; b) Damage sustained by crops; c) Coping methods of households with damage on crops; d) Assessment of success of coping methods for crops.

6.2.3.3 Coping with Impact on Infrastructure

Twenty-five and 24 houses in Tuatua and Nakodu respectively were completely destroyed by the unexpected tidal wave which occurred at the height of the cyclone, representing about 90% of all houses in these two communities, while the remainder had partly damaged roof and walls (Appendix G)

> "The roofs of the houses were blown away by strong wind and I saw the roof being dismantled by strong winds in the air. The three tidal waves destroyed the walls of most houses. It was the most terrifying life experience and I thank God that I am still alive today" (S.N, Nakodu, 07/07/2016).

Although houses were destroyed, no one died due to quick responses from community members. The majority of households whose houses were completely destroyed in Tuatua and Nakodu constructed makeshift houses using timber and tin soon after the cyclone (Fig. 6.6c). Most respondents were not satisfied with the makeshift houses because they leaked when it rained and were very hot when it was sunny (Appendix H).

Houses in all of these villages were not insured and rebuilding houses that were destroyed by the cyclone is likely to place a severe strain on household economies (Fig. 6.6a and b). It was reported by respondents that the Fiji government had promised households in all the villages whose houses were completely destroyed to help in the rebuilding process. Each household was allocated a sum of $7,000FJD worth of housing materials which could be purchased from a hardware shop. This amount was not intended to cover the cost of labour for building the houses. Despite this assistance, respondents stated that rebuilding their houses would be a challenge. .

Fifty two of the 122 households interviewed lost their fishing gear during the cyclone. All households that lost their fishing gear stated that this did not affect their household economy as most households in these three communities fish for household consumption only. More than 50% of households have bought new fishing gear while other households have not replaced their fishing gear.

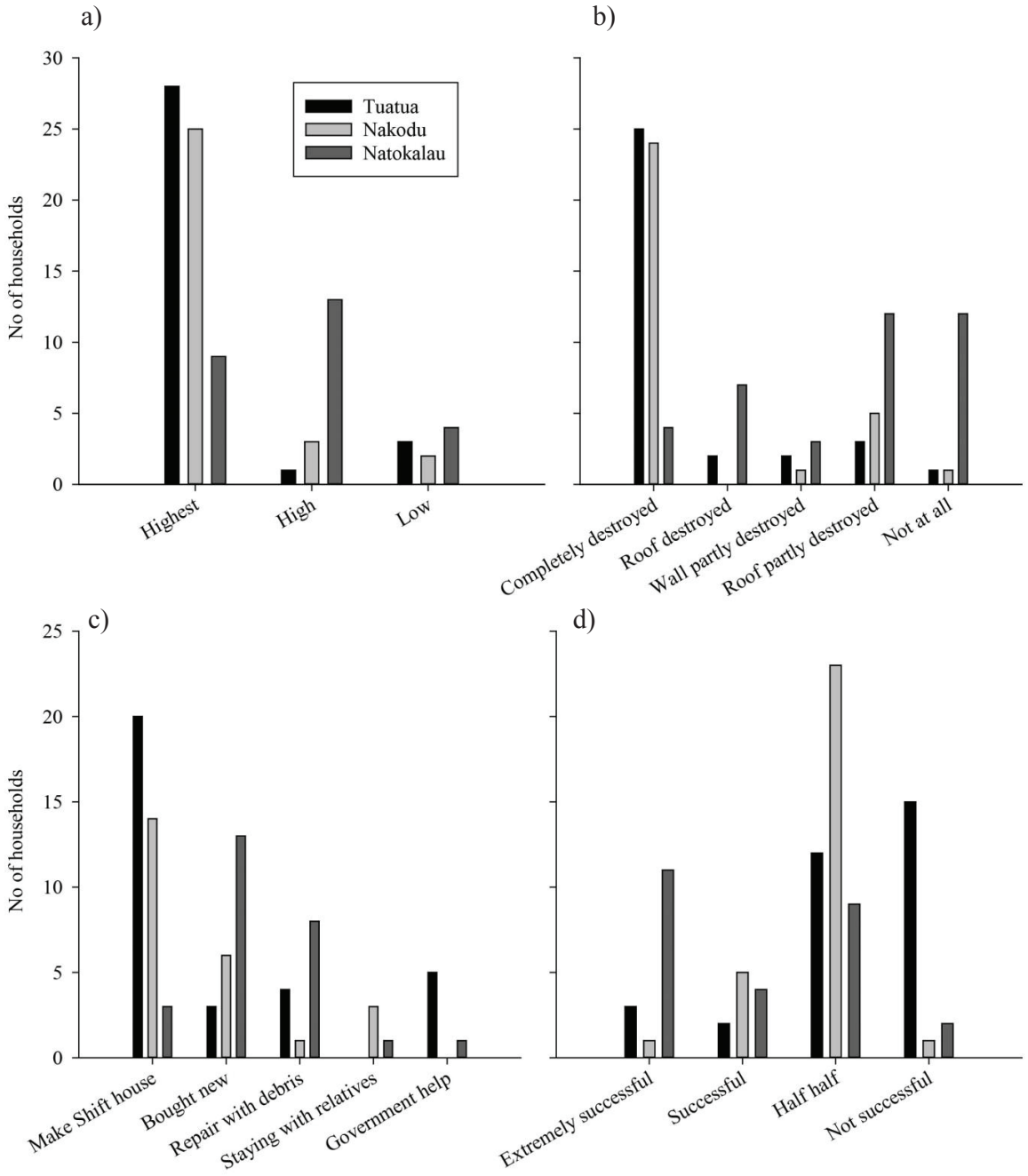


Figure 6.6: a) Impact of damage on house on household economy; b) damage sustained by houses; c) coping measures used by households; d) success of coping measures.

6.3 Discussion

6.3.1 Adaptation measures of communities and households

Adaptations are manifestations of adaptive capacity and they represent the different ways in which vulnerability can be reduced (Ribot, 2011). Adaptation does not occur instantaneously, therefore vulnerability of communities to decreases in reef resources and climate change would depend on the ability of households and communities ability to act appropriately in anticipating stresses (Brooks *et al.*, 2005). However it is important to note that adaptations can also be dysfunctional and increase vulnerability of coastal fishing communities (see Krause & Glaser, 2003). The devastating effect of a category 5 tropical cyclone which struck Fiji on February 2016 showed how adaptation chosen to address vulnerability to a certain stress (i.e. declining fisheries) could expose households and communities to another dimension of vulnerability to environmental stresses (i.e. storm damage to agriculture). Thus measures taken by individuals and households within a community can either act to facilitate or constrain adaptation. Moreover the stresses that require to be adapted to are a "moving target": adaptation measures that are successful as responses to a current threat my no longer be effective as circumstances change. For example, a previous study in Solomon Islands found that although economic strategies involving subsistence livelihoods adopted by households had been effective, population pressure may mean that this is not sustainable over the long term (Schwarz *et al.,* 2011).

Adapting to new livelihood portfolios can be difficult for most fishers, especially those who are strongly tied to fishing through occupational identity or place attachment (Marshall *et al.,* 2009). Increased access to assets may facilitate engagement in other livelihood portfolios (Cinner *et al.,* 2018) and enhance the occupational flexibility of fisher communities. However building assets may also enable coastal communities to exploit reef resources more intensively and thereby increase the vulnerability of communities to climate change (Cinner *et al.* 2018). For example wealthy households in Tanzania who had assets were more likely to exploit a decreasing fishery since they lacked flexibility to change livelihoods (Cinner, 2011). Thus the possibility of adopting new livelihood strategies does not mean that people will decide to do so. Unless people believe that alternative livelihood portfolios can produce desired outcomes and impede undesired ones, they will not adapt (Ajzen, 1991)

6.3.2 Adaptation through improved management of reef resources: implementation of *tabu* areas

Fishing for most fishers is a form of identity, way of life, and brings a degree of satisfaction which cannot be measured using economic indicators alone. Fishing is not only regarded as a means of securing a livelihood but "as an intrinsically rewarding activity in its own right – as a desirable and meaningful way of spending one's life" (McGoodwin, 2001:7). In Fiji and

Solomon Islands, fishing is part of the cultural heritage and a way of life, as discussed in chapter 4, and has positive connotations that go beyond being a source of income and livelihood for households. Fishing is considered a lifestyle, even when it is not the main source of livelihood This finding agrees with other studies that report high job satisfaction among artisanal fishers independent of whether fishing is a source of income or not (Pollnac *et al.,* 2001; Pollnac & Poggie, 2008). This is why many respondents indicated that they would continue fishing even if catches declined to half of present levels.

While fishers in Fiji and Solomon Islands do not fully understand the long-term implications of climate change for reef fisheries, they are aware that reef resources are currently under pressure due to overfishing and unsustainable fishing practices. Countering these pressures to maintain the productivity of the fishery is considered a priority. Communities in Fiji and Solomon Islands favoured the establishment of *tabu* areas, much more than any other measure (Table 6.3), in order to increase the abundance of fish and improve livelihoods. Apart from Yaro, Ligau and Daku, all communities in Fiji had an existing *tabu* area during the study period. Communities of Yaro, Ligau and Daku on Kia Island in Fiji previously had a *tabu* area, but this had been opened since 2012. In Solomon Islands the communities with existing *tabu* areas were Nusa Hope, Vanikuva, Rano and Bangopigo, while the communities of Kindu, Dunde, Kekehe and Lodumaho previously had *tabu* areas which were now opened. Raromana was the only studied community that had never had a *tabu* area. As reported in Chapter 5, most communities reported that the establishment of a *tabu* area had a positive effect on the fishery, although this was dependent on the degree of compliance.

The establishment of *tabu* areas has successfully replenished marine resources in several countries, including Philippines, Papua New Guinea, and Indonesia (Halpern & Warner, 2002; Cinner *et al.*, 2005; Mascia *et al,*, 2010; Jupiter & Egli, 2011; Cohen & Foale, 2013). However, socio-economic, cultural and political factors may limit the viability of this management approach in other regions (Aswani *et al.*, 2016; Foale & Manele, 2004; McClanahan *et al.*, 2008). In Melanesia, the concept of *tabu* has a long tradition: Spatial and temporal closures have traditionally been practiced in Fiji and Solomon Islands to show respect on the death of a prominent person in the community by protecting sacred sites and closing fishing grounds in preparation for the customary feasts (Hviding, 1998; Johannes, 1978). Thus fishing sites are closed in honour of people, especially chiefs, and re-opened. The period of closure, for example for 100 nights in Fiji, could be too short for the recovery of fish stocks but sufficient to increase the catchability of fish stocks for such social events (Jupiter *et al.*, 2014).

In recent years, establishment of *tabu* areas has been highly successful in most communities in Fiji under leadership of the Fiji Locally Managed Marine Areas Network (FLMMA). This can be attributed to learning success stories of *tabu* areas through peer-to-peer networks where communities meet and share experiences. However application of the concept in Solomon Islands has been less successful due to differences in tenure and political systems (Aswani *et al.*, 2017). Nonetheless, FGDs and KIIs in the communities of Dunde, Kekehe, Kindu and

Lodumaho, where *tabu* areas previously existed in Solomon Islands, stated that fish biomass and abundance had increased while the *tabu* areas were in place. Discussions with focus groups in communities in Solomon Islands indicated that more work is needed to get agreement between resource owners and other stakeholders before *tabu* areas are established. This supports the finding by McClanahan *et al.,* (2008) that adaptive capacity plays an important role in a community's preparedness to cope with restrictions imposed by *tabu* areas. Specifically, McClanahan *et al.* (2008) consider that high scores for adaptive capacity indicators such as infrastructure, social capital, financial capital and better alternative livelihood options are a prerequisite for the successful implementation of *tabu* areas. If a *tabu* area is implemented without adequate preparation, it may have the effect of increasing pressure on adjacent fishing areas, without any beneficial effect in terms of decreased vulnerability of coastal communities to decreasing reef resources

Management through the customary marine tenure (CMT) has also been recognized as a key in building adaptive capacity in the Pacific. CMT has rapidly changed under changing social, economic and ecological context where the need for food and income for livelihood has increased the harvesting of reef resources (Cinner & Aswani, 2007; Cinner *et al.*, 2007; Brewer *et al.*, 2012; Vaughan & Vitousek, 2013). CMT is a dynamic informal institution because it is generally unwritten, allowing flexibility in adapting to environmental changes (Hviding, 1998). Incorporating local and customary knowledge such as (CMT) into science and policy can enhance adaptation of households and communities (Berkes *et al.*, 2000)

The co-management of reef resources by various stakeholders has been linked to the success of *tabu* areas (Pomeroy *et al.*, 2001 Cinner *et al.*, 2012; Campbell *et al.*, 2013; Brewer & Moon, 2015). This success was not only in the improvement in the stakeholders' understanding of resource dynamics but also in its governance and behavioral components such as decisions and enforcement of rules that mediate resources use (Gutiérrez *et al.*, 2011; Dutra *et al.,* 2014; Dutra *et al.,* 2015).

Local leaders, institutions and organizations within the communities in Fiji and Solomon Islands can play a leading role in the implementation of adaptation measures for the management of reef resources such as *tabu* areas (Agrawal, 2010). The existence of NGOs working with studied communities in Fiji was vital for the success of *tabu* areas. Adaptation implementation has been found to be influenced by power relations and leadership styles and affected by behavior of local decision-makers in choosing and interpreting information available to them (Dutra *et al*., 2015). It could also be affected by how decision makers communicate with the people and how much people trust their decision makers (Folke *et al.*, 2005; Ostrom, 2010). The success of *tabu* areas can be related to level of trust and participation in community decision making. Rohe *et al*., (2017) found that non-compliance with marine tenure rules in Fiji and Solomon Islands were mainly driven by: 1) diminishing perceived legitimacy of local rules and rule makers; 2)increased incentives to break rules due to lack of alternative income and market access; and 3) relatively weak enforcement of local rules.

6.3.3 Adaptation through alternative livelihood strategies to anticipated future declines in reef resources:

The established of tabu areas and other measures suggested by respondents in Fiji and Solomon Islands to address the impacts of overfishing are unlikely to be effective in countering the long-term decline in reef resources that is predicted to occur as a result of coral bleaching and other impacts of climate change. This study therefore attempted to assess the adaptive capacity of communities in response to a future, irreversible decline in reef fisheries. Specifically, the study focused on households' willingness and ability to adopt alternative livelihood strategies.

The responses of fishing households to a hypothetical 50% decrease in catch differ significantly between Fiji and Solomon Islands and also within the two countries. Half of the respondents in the Solomon Islands would consider leaving the fishery if faced with a 50% decrease in catches, although an equal number stated that they would continue to fish. However, in Fiji a clear majority of the fishers stated that they would adapt their fishing practice and continue to fish even if catches decreased by 50%. Breaking down the results by community, it was found that fisher households in the eight out of nine communities in Solomon Islands (all apart from Dunde) and Nakodu and Tuatua in Fiji indicated they were likely to exit fisheries in response to a hypothetical 50% decrease in reef resources. By contrast, fisher households from most communities in Fiji and Dunde in Solomon Islands indicated they were likely to adapt fishing methods and gear and continue to fish even if catches decrease.

Reluctance to give up fishing may be due to a lack of alternative livelihood options for households and communities at their localities (Ikiara & Odink, 2000). Turner *et al.* (2007) found that the availability of an alternative source of income reduced fishing effort in a remote island in Fiji. Similarly, a study in Kenya, found that fishers prefer fishing to any of the other limited range of alternative occupations available to them (Cinner *et al*., 2008). In this study, none of the studied communities relied of fishing as their only source of livelihood, which is reflected in the low scores for 'sensitivity' report in Chapter 5. However a significantly greater number of households in Solomon Islands stated that farming was already their main source of income, which likely accounts for the greater willingness, on average, of households in Solomon Islands to give up fishing if catches decline significantly. Breaking down the results by community, most of the households in the ten communities (two in Fiji and eight in Solomon Islands) that indicated a willingness to leave the fishery stated that fishing was not their main source of livelihood (Fig. 5.3 a & b), and this was likely a key factor in the readiness to exit the fishery. The engagement of households in farming and other informal activities would facilitate their exit from the fishery.

Thus, overall, these findings support those of previous studies that households that rely on fishing as their main source of livelihood are less likely to exit fisheries (Ikiara & Odink, 2000; Cinner *et al.,* 2009; Muallil *et al*., 2011; Daw *et al.*, 2012). However, results from this study

highlighted that local socioeconomic and cultural contexts play a large role in determining the preferences of households and their willingness exit fisheries (also see Daw *et al.,* 2012). In particular the socio-economic indicators in communities where households indicated an unwillingness to exit the fishery displayed high variation. For example, fishing households in Muaivusu, Nabaka, Namakala and Waiqanake in Fiji were unlikely to exit fisheries even though they had ample alternative livelihood options because of proximity to the capital Suva. Respondents from KIIs and FGDs in these communities explained that fishing and gleaning of sea urchins (*Tripneustes gratilla*) had been their main source of livelihood for generations and it was also the easiest way for them to earn money. These communities own fertile land for farming but harvested crops were for subsistence use and not for sale. A respondent in Waiqanake said that "*farming takes time and energy, while with fishing, you catch fish or glean today and you are guaranteed cash on hand*" (M.V., Waiqanake, 26/11/2014). Similarly, fisher households in Dunde in Solomon Islands have access to land for farming but results show that most households did not farm and relied mostly on fishing and informal economic activities as their main source of livelihood. People prefer fishing because of the distance they need to walk to reach their farms.

Other studies have found that increased alternative livelihood opportunities for fishers and decreased opportunity costs would allow fishers to exit fisheries (Smith *et al.*, 2005). However, this was not the case in the communities of Muaivusu, Nabaka, Namakala, Waiqanake in Fiji and Dunde in Solomon Islands. Despite access to agricultural land, a high infrastructure index values which would facilitate engaging in alternative livelihoods, households in these communities choose not to do so. This was confirmed by the results of household surveys indicating that the proportion of households in these four communities whose members had changed jobs the last five years was low (see Chapter 5).

More detailed analysis of results from this study (Fig. 6.3) shows that households that ranked fishing as their main source of income *and* have a low MSL were more likely to stay in fisheries. This is consistent with other studies which found that poorer households are more likely to stay in a declining fishery than better-off ones (Cinner *et al.,* 2008; Daw *et al.,* 2012).

In this study MSL was found to be significantly correlated with occupational multiplicity, thus confirming the link between wealth and capacity to adopt alternative livelihoods (Table. 6.2). To eliminate collinearity, occupational multiplicity was thus removed from the statistical analysis. MSL was not significant in the GLM model for households exiting the fishery but it was a major factor influencing a decision to leave the fishery in the classification tree analysis. Conversely fishing households with low MSL were more likely to stay in fisheries faced with a hypothetical decrease in fish. Overall wealth, measured as MSL, was positively correlated to households' readiness to exit a declining fishery.

The reliance of poor household on a declining resource potentially creates "poverty traps" (Dasgupta, 1997; Barrett & McPeak, 2005; Barrett & Carter, 2006). This can be seen in Fiji and

Solomon Islands, where, households in more remote communities continue to rely on fisheries as a source of income, even though monetary return is low. Households in these remote locations have few material assets and cannot afford to take risks, and so it is harder for them to change their source of income than for rich households (e.g. Barrett *et al.,* 2006). Respondents from both Fiji and Solomon Islands stated that taking a loan from the bank was not an option because of high risks involved in meeting payments. Thus poverty could constrain poor households from adopting a different livelihood portfolio (Béné, 2003).

Households in the communities of Yaro, Ligau and Daku on Kia Island in Fiji who indicated they were unlikely to exit the fishery exemplified the 'poverty trap' referred to above. Fishing was their main source of livelihood (Fig. 5.3a) and households lacked alternative livelihood options (Jupiter *et al.,* 2012). Fisher households in these three communities indicated they would continue fishing regardless of perceived fish declines because this is their only source of livelihood. Moreover, as discussed in Chapter 4, the presence of a middleman in Yaro had increased fishing intensity in the three communities. Fishermen in these three communities reported that they fish day and night due to the presence of the middleman, who was prepared to buy any fish and other reef resources such as sea cucumbers from fishermen at any time of the day. Similarly, a study in Indonesia attributed a decrease in reef resources to "a widespread perception that there is a *punggawa* (patron) for anything that fishers collect and there will be always another marine resource to be targeted in case a particular species should become scarce" (Ferse *et al.,* 2014:2059). However the predicted increase of coral bleaching in the region as a result of climate change (see Chapter 5) means that such optimistic expectations are likely to be confounded. The lack of infrastructure and alternative livelihood options on island of Kia could lead households into a socio-ecological trap if the decline of reef resources intensifies as a result of coral bleaching (Barrett & McPeak, 2005; Cinner, 2011).

Households' readiness to exit the fishery was also influenced by more immediate experiences of fishing. The average catch on a normal day showed a significant negative correlation on readiness to exit the fishery. This is in agreement with other studies that report a negative relationship between normal daily catch value and readiness to exit the fishery; for example Daw *et al.* (2012) who found that fishers with a higher catch value are able to remain in the fishery as catches decline. Similarly, the classification tree analysis in this study showed that households that caught fewer than 20 fish on a normal day were more likely to exit the fishery.

The study also found that, in response to a hypothetical 50% decrease in catch, households that used a speargun were significantly more likely to exit the fishery while those that are engaged in trawling were more likely stay in the fishery. There were more households in Fiji that used a speargun, while trawling was mostly done by households in Solomon Islands. Since speargun fishers normally target bigger fish (Mangi *et al.*, 2007; Hamilton *et al.*, 2012), it was to be expected that fishers would exit this fishery when faced with declines, as this could reduce the catchability of large fish. However, the classification tree showed that most households in Fiji were unlikely to exit the fishery despite using spearguns. This was not the case only in Tuatua

and Nakodu, two communities where households do not rely on fishing as their main source of livelihood, Fishing is the main source of income for the fishing households in the other 8 communities in Fiji; thus people are likely to continue to use spearguns to sustain their livelihood despite a decrease in catches as reef resources decline.

6.3.4 Adaptation in practice: response of communities in Fiji to the impact of a category 5 cyclone

The devastating effects of the category 5 cyclone Winston on the communities of Tuatua, Nakodu and Natokalau in Fiji presented challenges for coping and adaptation of a different order from the incremental changes discussed in previous sections. Overnight, the cyclone destroyed crops and infrastructure including houses, boats, engines, post-harvest gear and fishing aggregation devices in the parts of Fiji situated along its path (Chaston *et al*., 2016). It also destroyed coconut plantations and pandanus plants for making mats which were a further source of livelihood. Household interviews revealed that communities were not prepared for such disaster. They made preparations based on their past experiences on cyclones, but were led astray by changing weather forecasts and were given no prior warning of the tidal wave which struck the communities.

Cyclones are nothing new in the tropical Pacific, but they are predicted to increase in both intensity and frequency in the near future (Emanuel, 2005; Knutson *et al*., 2010; IPCC, 2012), exposing island populations to previously unforeseen risks. Cyclone Ita, which made landfall in April 2014 in Australia, destroyed forests and farms, exposing forest systems to invasive plant species at the expense of endemic species (Goulding *et al.*, 2016). Category 5 cyclone Pam, which struck the islands of Vanuatu in the Pacific in 2015, destroyed infrastructure and forests and affected 80% of the food production (Esler, 2015).

The experience of cyclone Winston highlights a number of issues that are pertinent for adaptation to declining reef resources by households in Fiji and Solomon Islands, as well as more general lessons for the development of adaptive capacity on the islands. Mangubhai (2016) reports that cyclone Winston also damaged coral reefs, especially near the eye of the cyclone in the north of Fiji. There was no data collected on fish biomass but it was speculated that the reduction in corals and reef structure would negatively affect the abundance and biomass of certain fish species and other reef organisms (Manghubhai, 2016). However, it was the effects on agriculture that were felt most acutely in the communities of Nakodu, Tuatua and Natokalau, where families relied on farming as their main source of livelihood as reported in Chapter 5 (Fig, 5.4). Overall the cyclone was less destructive Natokalau than in Nakodu and Tuatua. Households in the former community were also less fully dependent of agriculture, and benefitted from incomes of family members employed at PAFCO.

Elsewhere in this study, households from the communities of Nakodu, Tuatua and Natokalau were considered less vulnerable to decreasing reef resources since they relied more on farming and other economic activities (see Fig. 5.4 in Chapter 5). However reduced vulnerability to decreasing marine resources was matched by increased vulnerability, particularly in Nakodu, Tuatua, to the catastrophic effects on agriculture caused by a category 5 cyclone. By contrast, the availability of a further alternative livelihood source (income from employment) helped households in Natokalau cope with the disaster.

The experience of the cyclone highlights that adaptation depends not only on diversification among livelihoods but also on diversification within livelihoods. The three communities of Tuatua, Nakodu and Natokalau mainly planted cassava, taro and *kava* for food and income. Very few farmers planted a variety of vegetables and crops such as sweet potatoes, yams and other species of taro which can withstand cyclones. Due to lack of availability of seeds on the island, households in Natokalau, Nakodu and Tuatua had to wait for weeks to receive seedlings vegetables, sweet potatoes, and taro from government. In Tuatua and Nakodu it took four months before farmers could grow these seedlings. It has been argued that when social systems or communities depend on a single resource, they tend to be more likely impoverished and are less resilient and more vulnerable to sudden changes (Adger, 2000; Stedman *et al.*, 2004; Adger *et al.*, 2005; Stedman *et al.*, 2011). Therefore the move from diversified subsistence to monocultures for cash cropping which provide material well-being for households may lead to high vulnerability to stresses such as cyclones (Folke *et al.,* 2003). Similarly, for fisheries, economic development in coastal communities promoted by the presence of freezers, motorised boats and use of nets may increase income of households, this can intensify exploitation increasing the vulnerability of communities (Cinner *et al.*, 2016).

Following the cyclone, it took months before households could harvest their crops and in the meantime families remained dependent on food rations from government and fishing to supplement their diet. Thus, while this study has considered agriculture as a means of reducing vulnerability to declining reef resources, in the case access to reef resources reduced the vulnerability of the communities to the effects of the cyclone. It is worth noting however that the destruction caused to agriculture could indirectly lead to overexploitation of reef resources due households' increased reliance on these resources during the time when they are unable to harvest or plant crops.

Reflecting on the experience, households in Nakodu, Tuatua and Natokalau stated that the three most important things needed in the aftermath of the cyclone were food, clean drinking water and shelter. In preparation for future cyclones respondents mentioned the need for communities to have a savings account and recommended the planting of hurricane-resistant crops, such as sweet potato and yams, as well as improvements to infrastructure (strong houses, evacuation centres, radio and relocation of village). Social assets (spiritual life and media) also needed to be strengthened in order to withstand a future category 5 cyclone (Fig. 6.5). Residents indicated that strong social cohesion, evidenced by trust in community leaders and other people in these

communities, was their source of strength in coping and undertaking rehabilitation work after the cyclone (Chapter 5). Key informants interviewed in these communities stated that the cyclone brought the community together in their struggle to survive. The communities ate together for days, assisting one another in every way they could in terms of cleaning the community, rebuilding houses and gathering of food. This experience agrees with findings of other studies that trust and social cohesion within communities play a vital role in making people willing to work together and support one another when extreme climatic events occur (Barnes *et al.,* 2017).

6.4 Conclusion

Successful management of social-ecological systems requires not only the analysis of the indicators of vulnerability but also a better understanding of the interaction of social, cultural and economic mechanisms that make people vulnerable and the contextual changes that drive resource use patterns (Turner *et al.*, 2007; Schipper & Dekens, 2009). Fisheries diversification and occupational diversity have been reported as important to address environmental and economic changes so as to contribute to the viability and welfare of fishing communities (Allison & Ellis, 2001; Cinner & Bodin, 2010). However, when planning such adaptations, it is essential to assess the practicality, feasibility, chances of success, local need and support for these strategies at the local level based on the capability of communities according to their assets, learning, social organization, flexibility and agency (Cinner *et al.,* 2018).

This study has found strong evidence that the provision of alternative livelihoods could reduce fishing pressure in Fiji and Solomon Islands through reduction in fishing effort, but this will not stop fishers from fishing, as shown by previous work (Matiya *et al.,* 2005; Sievanen, *et al.*, 2005; Cinner, 2011; Hill *et al.,* 2012). Adaptations that are considered successful by people affected by a stress depend on what people perceive to be worth acquiring and protecting (Schwarz *et al.*, 2011). Fishing is a way of life for most households in Fiji and Solomon Islands, and the interest of households is currently focused on measures to sustain the fishery, such as implementation of *tabu* areas. However there is a need for livelihood diversification into other sectors (whether people want it or nor not) as reef resources are unlikely to be sufficient to sustain livelihoods in the future. Households with few alternative livelihood options, particularly when coupled with a low assets base, will remain highly vulnerable to decreasing reef resources and climate change-related events such as coral bleaching and cyclones.

As indicated in the forgoing discussion, the ability of the communities Nakodu, Tuatua and Natokalau to successfully cope with this extreme climate event has lessons for adaptation to declining coral reef fisheries in Fiji and Solomon Islands. It should be borne in mind that while declines in reef resources have until now been incremental, reefs are predicted to become increasing exposed to catastrophic changes—comparable to a cyclone—as a result of climate change-related bleaching events. Respondents from these three communities demonstrated an awareness of the importance of good access to social, natural and human assets in order to decrease vulnerability to such events and foster adaptation. They also highlighted the vital role

played by trust and social cohesion in determining whether or not people will help each other when natural hazards occur (Barnes *et al*., 2017). Pacific Island nations/communities have demonstrated the ability to cope with climate variability in the past (Bell & Taylor, 2015), but the increased intensity and frequency of climate-related changes now threaten communities on multiple fronts. The greatest challenge is to enhance the adaptive capacity of households and communities while not undermining ecological systems, in order to deal with disturbances and to build preparedness to inevitable changes (Folke *et al.*, 2003). Responding to this challenge will require adaptive capacity in terms of flexibility to change strategies, ability to organize and act collectively, learning to recognize and respond to change, and the agency to determine whether or not to change (Cinner *et al*., 2018). To this end, measures are required to provide individuals, households and communities access to the physical (e.g. infrastructure), natural (e.g. water resources), human (e.g. education and health), financial (e.g. income, savings and credit) and social (kinship networks and associations) assets needed to enhance their adaptive capacity (Allison & Ellis, 2001; Muallil *et al.,* 2011Nelson *et al.,* 2007; Cinner *et al.,* 2009).

7 Chapter 7: Conclusions

This research sheds new light on factors influencing vulnerability and the development of adaptive capacity among coastal communities in the tropical Pacific region in response to decreasing coral reef resources and to the impacts of climate change. It has also highlighted a number of areas where further research would help to fill gaps in the present study and/or deepen understanding of key issues that have been identified. This final chapter summarizes the key finding of research, their implications for communities and decision makers, and outlines recommendations for future research.This research aims to support households, communities and relevant stakeholders in Fiji and Solomon Islands in addressing vulnerability to decreasing reef resources by providing new knowledge on fisheries management and building adaptive capacity in response to climate change.

7.1 Key Findings

7.1.1 Research questions and conceptual framework

This study addresses the following research questions (see Chapter 1):

1. What are the drivers of reef resource use in Fiji and Solomon Islands?

2. What are the different factors that determine the livelihood vulnerability of a household and community changes in reef resource availability and climate change?

3. How are the livelihoods of households and communities affected by a decrease in reef resources and climate change?

4. What adaptation options do households have to respond to different stresses and scenarios of change?

In order to address the above research questions, vulnerability and sustainable livelihoods conceptual frameworks (see Chapter 2) were employed to understand and assess current livelihoods of households and communities, the exposure and sensitivity of these livelihoods to stresses, and the potential adaptation options available.

7.1.2 Drivers of reef resource use in Fiji

The study used the results of household interviews, key informants interviews and focus group discussions to elucidate proximate and distal drivers of reef resource use in Fiji and Solomon Islands, from the perspective of resource users.

Access to new fishing gear and adoption of new fishing methods were found to be the only proximate driver of reef resource use. Distal drivers identified included (1) requirements for food and income, (2) increase in population, (3) access to markets, (4) the need for monetary incomes to meet cultural and religious obligations, and (5) the continuing importance of fishing as a 'way of life' (see Table 4.1 in Chapter 4). In this study distal drivers are referred to factors that indirectly affect reef resources and proximate drivers are factors that directly affect reef resources. These drivers maintain and increase fishing pressure on reef resources, interacting in sometimes complex ways that vary between the two countries and among communities.

Respondents in all communities reported an increase in the number of households and inhabitants in recent years. Communities in both countries are experiencing endogenous population growth, i.e. more children are being born; respondents in Solomon Islands also reported that the population had grown due to inward migration for work or marriage. Population growth can be expected to lead directly to greater fishing pressure, for (at least) two reasons: Firstly, people in both countries continue to rely on fish as the major source of protein in the diet. Coastal communities in Fiji and Solomon Islands obtain 92% and 97% total protein intake, respectively, from consumption of fresh fish (Bell, 2009). Secondly, fish and fishing are seen as part of the 'way of life' in both countries. In addition to its importance for livelihoods, fishing is of great cultural significance and is practiced for recreational and ceremonial purposes, as well as to acquire status in the community and even for courtship.

Compounding increased population is the growth of the commercial fishery. Traditionally households in Fiji and Solomon Islands fished only for subsistence, i.e. direct consumption, as elsewhere in the Pacific (Johannes, 1981; Gillett, 2009; Bell *et al.,* 2015; Young *et al.,* 2016). This study finds that this is still the case in some households that have an alternative source of income (usually agriculture). Many other households (67.91% of all households in Fiji and 68.13% in Solomon Islands) now fish for food and income, prioritising one or the other, as the following quotes illustrate.

> "I fish mainly for my family first and the rest is sold. It does not matter if I do not have any fish to sell as long as I have fish for my family to eat" (K.D, Muaivusu, Fiji, 02/12/2014).

> "I would rather sell the fresh fish that I catch and buy canned tuna from the shop" (G.H, Dunde, Solomon Islands, 27/02/2014).

The growth of commercial inshore fishery i.e. exploitation of inshore reef resources by local fishers for commercial ends; mirrors developments elsewhere in the Pacific, where fishing is

now a major source of income for most coastal communities (Bell *et al.,* 2009). It is driven in the first place by the need for cash incomes to meet basic needs, such as food and education. In addition, especially in Fiji, cash is needed to meet social obligations, i.e. the payment of church levies and community charges. For example, on Kia Island in Fiji, the need to raise funds for community projects was cited as the reason for opening up formerly protected *tabu* areas for fishing. Increased access to markets with good infrastructure for example through middlemen in the community, not only facilitates but also drives the increase in commercial fishing. Middlemen that are prepared to buy all the fish that is landed in the community act as a powerful incentive for households to continue fishing. Adoption of modern fishing gears, in particular the speargun, has further increased pressure on reef resources. Spearguns not only enable fishers to catch more fish in a shorter time with less effort, they also make it easier to target larger fish of the species preferred by consumers. Furthermore, spearguns can be used with torches to fish at night. Although still only owned by a minority of households (31% in Fiji and 10% in Solomon Islands; see Chapter 4), spearguns are transforming the fishery sector in both countries. In particular, night spearfishing is widely used by communities in Fiji and Solomon Islands as a strategy to increase catches (Hamilton *et al*., 2012; Jupiter *et al.,* 2012), and in this study is identified as a key contributor to decreasing reef resources by respondents in both countries.

7.1.3 Factors that determine the livelihood vulnerability of a household or community to changes in reef resource availability and climate change

- The key finding was that livelihood vulnerability of a household or community to changes in reef resource availability and climate change is contextual.

Livelihood vulnerability to changes in reef resource availability and climate change was measured in this study as exposure plus sensitivity minus adaptive capacity using unweighted averages of the three indices, giving a range of values for vulnerability of between 0 and 1, where 1 indicates the highest vulnerability (see Chapter 3). The overall national vulnerability index was higher in Solomon Islands (mean = 0.65, SD = 0.06) than in Fiji (mean = 0.59, SD = 0.10), indicating that communities in Solomon Islands were more vulnerable to changes in reef sources and coral bleaching compared to communities in Fiji (Fig. 5.1 and Tab. 5.1). However, scores were highly variable among communities in both countries. In most cases sensitivity index values were relatively low and adaptive capacity index values were high (Table 5.1). Overall differences in vulnerability were primarily determined by levels of exposure, and secondly by differences in adaptive capacity.

Exposure was calculated by combining data on households' perception of reef resources and of the likelihood of future coral bleaching over the next few decades based on predictions of climate change scenarios (van Hooidonk *et al.,* 2014). Thus the index combines two very different measures of exposure: perceptions of changes in the recent past and predictions of changes in the mid-term future. Perceptions of the current condition of reefs varied between

countries and were found to be highly correlated to the perception on effectiveness of resource management, specifically the existence of functioning *tabu* areas. A majority of households in all communities in Solomon Islands, where there were no *tabu* areas, considered reef resources to be declining. By contrast only 7 of 10 communities in Fiji, had *tabu* areas in operation, indicated that marine resources were increasing. In the Fijian study sites only the communities on Kia Island (Daku, Ligau, Yaro) indicated that marine resources were declining, and respondents reported that the decline occurred following the opening of the *tabu* area around the island. Respondents in communities in Munda (Dunde, Kindu, Kekehe and Lodumaho) in Solomon Islands reported a similar experience.

Exposure to future coral bleaching could be related to physical conditions, with corals in shallow, enclosed waters (Nusa Hope and communities in Munda and Solomon Islands, and Kia Island in Fiji) more vulnerable to bleaching in the short to medium term than those adjacent to open waters. However the key finding of this analysis was that, even under the most optimistic scenario that global CO_2 emissions will stabilize by 2100, all studied communities are expected to experience annual coral bleaching with the next 40 years. These are findings from van Hooidonk *et al.* (2014) on future coral bleaching events based on different climate change scenarios (Table 5.2).

Sensitivity to decreasing reef resources in this study was measured as reported dependence on reef resources, with values ranging between 0 and 1. Sensitivity scores in all communities were low, because most households surveyed in both countries also engaged in farming and informal economic activities, which decreased their sensitivity to declines in reef resources. Communities with higher sensitivity scores were those where more than 50% of households ranked fishing as their main source of income, i.e. Daku, Ligau, Yaro, Namakala, Nabaka and Waiqanake in Fiji and Dunde in Solomon Islands. In the three communities on Kia Island in Fiji (Daku, Ligau and Yaro), where there is limited land to grow crops, fishing is the main source of livelihood and some households were totally dependent on reef resources for food and income.

It is important to note that these scores only measure sensitivity to decreasing reef resources. As demonstrated when cyclone Winston hit communities in Fiji in February 2016, reliance on agricultural production is subject to its own risks, particularly those associated with extreme climate events, which are likely to become more frequent and severe as a result of ongoing climate change (Emanuel, 2005; Knutson *et al.,* 2010). In the three communities worst affected by the cyclone (Nakodu, Tuatua and Natokalau), access to reef resources can be considered to have reduced the sensitivity of households to the impacts on agriculture. Thus combining agricultural production and fishing reduces sensitivity to events that impact on one or other source of livelihoods. But fishing gear was also lost and damaged in these three communities as a result of the cyclone. Sensitivity of households to an extreme event that affects both farming and fisheries is likely to be high.

Adaptive capacity was measured in this study using 12 indicators, which were grouped together into the five livelihood assets identified by the Sustainable Livelihoods Framework (SLF), namely social, physical, human, natural and financial assets (Table 6.1, see Table 3.6 for details of how scores were calculated).

Table 7.1: Adaptive capacity indicators considered in this study, as related to the five sustainable livelihood assets identified by the Sustainable Livelihoods Framework.

Sustainable Livelihood Asset	Indicator
Social	Trust
	Community network
Physical	Material style of life
	Infrastructure
	Gear diversity
Financial	Access to credit
	Debt
Human	Human agency
	Occupational multiplicity
	Occupational mobility
	Capacity to change
Natural	Access to land

Analysis of the results revealed some scope for improvement in the construction of the index. Material style of life (MSL) and infrastructure were found to be highly correlated, as were debt and access to credit. Thus, to eliminate duplication, each of these pairs of indicators could be combined into a single indicator. Some indicators of adaptive capacity that became apparent in the field work, notably access to markets (see Chapter 4) and participation in decision making (Chapter 5), are not represented in the index. Other key indicators are measured only indirectly and should possibly be given greater weight in the index. These include education (partially covered by human agency, which was calculated based on knowledge of the causes of decreasing reef resources) and institutional capacity (partially covered by trust, i.e. answers to questions about trust in institutions).

Results revealed complex differences in adaptive capacity between countries and among communities. Overall scores for adaptive capacity were slightly higher for Solomon Islands than for Fiji, but the make-up of these scores was very different between the two countries. In general terms, while households in Fiji scored more highly for trust and infrastructure/MSL (hereafter 'MSL'), they had lower scores for occupational multiplicity and mobility, and very low scores for 'capacity to change', which was measured as their stated willingness to change (for example, fishing gear, fishing location) in response to a hypothetical decline in fish catches. By contrast, households in Solomon Islands had low scores for trust and MSL, but more experience of work outside the fisheries sector and a greater willingness to change. A nuanced understanding on the differences in adaptive capacity of communities in Fiji and Solomon islands is needed when designing and prioritizing adaptive strategies in order to reduce vulnerability of communities. Therefore adaptive strategies should target to improve factors communities had low scores.

Permutation cluster analysis further revealed the existence of two broad clusters of communities in each country. In Fiji, the three communities of Kia Island (Daku, Ligau and Yaro) had very low scores for MSL and access to agricultural land but high scores for trust and community network. As a result Daku in particular obtained a high score for adaptive capacity (highest of all communities in Fiji), despite the community's lack of material resources and almost complete reliance on fishing for food and income. This shows that lack of material resources cannot be assumed to imply lack of adaptive capacity. It is important to understand that Daku was also a small community with only 8 households.

At the other extreme from Daku was Nabaka. This community obtains most of its food and income from fishing with gillnets, despite having access to good quality agricultural land. The community obtained high scores for MSL and access to agriculture, but levels of trust in the community are very low, and their unwillingness to leave the fishery was reflected in a very low capacity to change. Thus, despite the community's access to material resources, it obtained the lowest score for adaptive capacity among all communities in Fiji. The ability of households to change livelihood portfolios does not depend on the availability of alternatives but on other factors as well. For example the cultural significance and self-identity people have on fishing could affect implementation of adaptive strategies. In Solomon Islands, the four communities in Munda (Dunde, Kekehe, Lodumaho and Kindu) formed a cluster with distinct characteristics. Compared to other communities in Solomon Islands, households in these communities had a higher MSL and more experience of work outside the fisheries sector, relatively good access to credit, but very low levels of trust in other community members, community leaders and institutions. Communities in the other cluster with fewer material resources (e.g. Bangopigo, Rano, Vanikuva and Nusa Hope) generally recorded higher levels of trust in village leaders, other households and NGOs.

It is thus notable that, in both Fiji and Solomon Islands, there appeared to be a negative correlation between 'trust' and material style of life; however more research is needed to better understand this relationship.. In general, most or all communities obtained low scores for access

to credit and educational attainment (measured indirectly as 'human agency') as well as for participation in decision making in the community were identified as priority issues to address in order to increase adaptive capacity.

In summary, overall results for vulnerability reveal a high degree of heterogeneity between countries, among communities in each country and among households within individual communities, although differences are not always apparent from a simple comparison of aggregate index scores. Aggregate scores for vulnerability to decreasing reef resources are largely determined by exposure (i.e. the extent to which local resources are affected), over which households and communities have limited (and decreasing) control. Adaptive capacity also contributes significantly to differences in vulnerability among communities and households; similar findings are reported by Adger (2003) and Smit & Wandel (2006). However, adaptive capacity was found in this study to be highly context-dependent and composed of a number of attributes such as MSL, infrastructure, trust, access to land that were interrelated in complex ways. Adaptive capacity is also difficult to measure directly and an alternative index, constructed in a different way, could shed a different light on relative levels of adaptive capacity among households and communities in this study. Although adaptive capacity index used in this study was able to determine vulnerability of households and communities to changes in reef resource availability and climate change, other factors such as power, institutions, gender, education and governance should be considered in future studies. Further development of adaptive capacity is essential in the light of predictions of future effects of climate change on livelihoods, via impacts on coral reefs, fisheries, agriculture, infrastructure and the wider economy.

7.1.4 Effects on household livelihoods of decreasing reef resources and climate change

- The key finding was households that have access to other alternative livelihoods were less affected by decreasing reef resources. However they would still experience impacts from decreasing reef resources and climate change, since fishing is still important for their livelihoods as a source of protein, as well as culturally and as a 'way of life'.

Respondents in both countries reported that there is increasing pressure on reef resources due to local population growth. In Solomon Islands, respondents considered that reef resources were decreasing; however in Fiji reef resources were reported to be increasing, except on Kia Island, where they were said to be declining. In both countries, problems of the fishery mentioned by respondents related predominantly to different aspects of access to markets: the presence and behaviour of middlemen, cost of fuel, and lack of facilities for transportation and storage. If impacts on fisheries are currently being experienced, they are likely manifested as declining catch per unit of effort (CPUE). While declining CPUE can often be an indicator of overfishing it is easier to detect through studies of the whole fishery than from perceptions of individual

fishers (Kolding *et al.* 2014). In this study, respondents were not asked about CPUE but on the different species of fish that they catch and whether it was increasing or decreasing.

Impacts of decreasing reef resources on livelihoods will also depend on the extent to which communities have access to alternative sources of protein and income. In Fiji and Solomon Islands, as elsewhere (Metcalf *et al.*, 2014), coastal communities differ in their reliance on reef resources for their livelihood. In the selection of communities for this study, it was assumed that they were all highly dependent on reef resources as their main source of livelihood. Results of the research indicated that this was not the case, since households studied had some alternative source of livelihoods which were ranked higher than reef resources in some of the studied communities. Moreover, households in some communities in both Fiji (i.e. Natokalau, Nakodu and Tuatua) and Solomon Islands (e.g. Bangopigo, Vanikuva and Rano) depended on crops and other informal activity as their main source of livelihood. These households are therefore less sensitive to declining reef resources. However they would still experience impacts from decreasing reef resources, since fishing is still important for their livelihoods as a source of protein, as well as culturally and as a 'way of life'.

Similar considerations apply when assessing the probable impacts of a future collapse of coral reef fisheries as a result of coral bleaching due to climate change. While the impact on fish availability would obviously be severe, the impact on livelihoods would depend on (1) the extent to which other sources of livelihood (e.g. agriculture and tourism) were also impacted by climate change and (2) the extent to which households had been able to adopt other 'climate proof' ways to access food and income. The latter will in turn clearly depend on the development of adaptive capacity among households and communities.

7.1.5 Adaptation options for households and communities

- The key finding was that adaptation to climate change is a 'moving target': Adaptation options that work today may not be effective in the future. There is a danger of 'maladaptation' (Barnett & O'Neill, 2010), where actions taken to avoid or reduce vulnerability to climate change impact adversely on, or increase the vulnerability of other systems, sectors or social groups.

In response to current threats to reef resources, the adaptation options advocated and adopted by households and communities include (1) improved local fisheries management (e.g. implementation of restriction such as *tabu* areas or gear restriction) and (2) diversification of fishing households into agriculture, paid employment and informal trading.. But these adaptation strategies are unlikely to be effective if, as expected, the impacts of future climate change on both fisheries and agriculture become more severe. For example the effect of cyclone Winston on the communities of Tuatua and Nakodu in Fiji where all crops were destroyed showed that

communities can be highly vulnerable if adaptation is based on one portfolio such as farming. Diversification of livelihoods is important in reducing vulnerability of households and communities.

Inhabitants of Fiji and Solomon Islands place a high value on their reef resources and households in coastal communities in this study displayed an awareness of problems caused by overfishing. However, most households are unaware of the link between climate change and coral reef destruction, except in two communities where training courses on climate change had been held (Muaivusu and Nabaka in Fiji, see Fig. 5.12). Therefore it is unsurprising that the adaptation option most frequently mentioned by respondents was improved fishery management, specifically through the establishment of *tabu* areas.

Tabu areas are a management strategy that is understood by local people and with a proven record of success, although more so in Fiji than Solomon Islands. Aswani *et al.* (2017) identified a range of cultural, political and geographic reasons to explain the difficulty in adopting this strategy in Solomon Islands. According to the results of surveys carried out for this study, *tabu* areas were considered to be functioning well in terms of providing fish in seven out of ten communities in Fiji, i.e. they were perceived to be associated with an increase in reef resources in these communities. Respondents in a further seven communities (four in Munda in Solomon Islands, and three on Kia Island in Fiji) reported that *tabu* areas had previously been effective in protecting marine resources, and that these had declined when the restrictions on fisheries were lifted. Four communities in Solomon Islands had *tabu* areas that were considered only partially successful, due to incomplete compliance (Nusa Hope) or the distance of protected area from the communities. Raromana in Solomon Islands was the only studied community that has never had a *tabu* area.

The establishment of protected areas, or implementation of other fishing restrictions mentioned by respondents, such as a ban on night fishing, clearly require action at the community level. Both the decision to establish a *tabu* area and control over its implementation have to be assumed by the community, since they require individual households to forego short-term benefits of unrestricted fishing in the interests of the long-term sustainability of communal resources. This in turn requires strong local institutions that are trusted by local households. Although this study did not directly address the issue of institutions, the implementation of *tabu* areas in Fiji was linked to successful functioning of the nationwide Fiji Locally Managed Marine Areas Network (FLMMA). Levels of trust, particularly in NGOs, were also notably higher in Fiji than in Solomon Islands. It appears then that strong local institutions can give rise to a 'virtuous circle' in which strong institutions generate trust, which in turn strengthens the institutions. By contrast, households in four communities in Munda, Solomon Islands, where a previous *tabu* area had been reopened displayed the lowest levels of trust among all the communities surveyed. However, households on Kia Island in Fiji where a previous *tabu* area had been reopened, displayed very high levels of trust on community members highlighting the context-dependent nature of relations between adaptive capacity indicators.

In contrast to fisheries management, adaptation to threats to fisheries by diversification into agriculture and/or other livelihoods is a decision that is taken at the household level. As noted in Chapter 6, reliance on agriculture for livelihoods exposes households to other risks, including crop losses as a result of extreme weather events. The experience of the communities hit by tropical cyclone Winston showed that diversification provides 'two-way' protection: agriculture provides resilience to declines in fisheries, but fishing helps mitigate the impact of crop losses caused by extreme weather events. This of course begs the question of how households would cope with an extreme climate event that damaged both fisheries and agriculture, an occurrence which climate change scenarios suggest will become increasingly probable as global temperatures rise (Badjeck, *et al.,* 2010; Zhao *et al.,* 2017).

In the longer term, climate change scenarios suggest that catastrophic coral bleaching is a near certainty in the region (Van Hooidonk *et al.,* 2014). The projected increased frequency and intensity of tropical cyclones, and associated tidal waves (IPCC, 2007), also represents a severe threat to agriculture and probably tourism as well. Unlike a decrease in reef resources due to overfishing, these are threats whose timing is unpredictable and over which households and communities have no control. The measures required to build adaptive capacity in response to these threats are further discussed in the following sections.

7.2 Implications for households and communities

The principal message of this research for coastal communities in Fiji and Solomon Islands is that climate change poses an existential threat to their coral reefs and the marine resources as well as other livelihood resources such crops. However, the timing and extent of future coral bleaching events remain uncertain and possible mitigation measures may still be identified. Thus it makes sense to do everything possible to maintain the health of coral reefs and their fisheries, while 'preparing for the worst' by diversifying into alternative livelihoods, including—but not exclusively—agriculture.

Households and communities should support existing *tabu* areas and work to (re-)establish *tabu* areas where they do not currently exist. In addition, consideration should be given to further management measures, such as prohibiting night fishing, while recognising that trade-offs will need to be made between the benefits (for example improved education) of increased household incomes now and longer-term benefits of maintaining the health of the fishery. To enable informed decisions to be made, measures will be required to strengthen community organizations such as youth groups, bring on board those that are trusted by local people, and increase the involvement of local people, including both men and women, in decision-making. Communities should also strengthen cooperation with government agencies and NGOs, in order both to take advantage of the support that these organizations can offer.

These measures to strengthen local institution in reef management will ensure that households and communities are better prepared to adapt to an uncertain future and cope with unexpected future shocks in an era of global climate change.

7.3 Implications for decision-makers

This study -finds that overall vulnerability of households and communities to decreasing reef resources is determined largely by exposure to fishing pressure (in the short term) and coral bleaching caused by climate change (in the longer term). Long-term exposure, as defined in this study, is clearly an aspect of vulnerability over which individual households and communities have no control. Moreover climate change poses an increasing threat to other economic sectors on in both countries, and most study communities including agriculture and tourism. Thus increasing adaptive capacity is essential both to enable households and communities to cope with shocks when they occur, and to facilitate the adoption of alternative livelihoods that are less dependent on climate-vulnerable resources.

A key message of this study is that adaptive capacity is highly context dependent. Thus there are no universal 'recipes' for strengthening adaptive capacity and measures taken to this end should be adapted to local circumstances. Nevertheless, this study reveals some common areas of weakness in adaptive capacity across communities in both countries, such as poor educational attainment and lack of access to credit. Moreover, the experience of cyclone Winston provided a valuable 'rehearsal' for the challenges that are to come, from which some lessons of general validity can be learned. The experiences of households in Nakodu, Tuatua and Natokalau in the aftermath of the cyclone confirmed the importance of trust and social capital in enabling communities to cope with unexpected extreme events. It was also notable that the existence of a third source of income, from employment at the Pacific Fisheries Company on the island, among households in Natokalau facilitated reconstruction in this community. At the same time, as emphasized by households interviewed for this study, the cyclone highlighted the need to improve early warning systems and disaster preparedness plans.

Drawing on these results and experiences, the following policy recommendations for decision makers are made:

- Channel resources into improving education, so that inhabitants in fisher communities are better prepared to assume alternative employment.
- Improve the provision of information (publicity campaigns, training courses) to raise awareness of climate change among coastal communities and support adaptation by households and communities.
- Establish mechanisms to provide access to credit to households.
- Provide support for improved infrastructure and access to markets.

- Provide support to strengthen marine management committees and other local institutions to enable communities to take and implement informed decisions about the management of reef resources.
- Improve and/or set up early warning systems and disaster preparedness plans.
- Actively seek to attract inward investment to develop new economic activities that are less dependent on climate-dependent natural resources.
- Involve local people in policy making to ensure that measures taken correspond to local needs.

7.4 Implications for future research

This research has highlighted the contextual nature of livelihood vulnerability.. This study clearly shows and expands on the knowledge on the complexity in determining the livelihood vulnerability of household and communities to changes in reef resource availability and climate change. The calculation of the vulnerability index using indices of exposure, sensitivity and adaptive capacity cannot be assumed to fully show vulnerability of households and communities. Individual analysis of the individual assets such as social, human, natural, physical and financial as shown in this study is vital in understanding point of departure for coping and adaptive strategies. Adaptive strategies chosen by households may not be the most suitable as this can increase vulnerability in other systems..

The findings and conclusions of this research highlight a number of areas where further research is required to deepen understanding of vulnerability to climate change and foster the development of adaptive capacity among coastal communities in Fiji, Solomon Islands and the wider tropical Pacific region.

- To facilitate comparative analysis, the sites chosen for analysis were all local fishing communities that have or have had an MPA. Future research should also include sites without this type of marine management to better understand and compare factors that affect a wider range of households and communities.
- The indicators used in this study to measure exposure were incomplete. Measurement of current and near-future exposure based on the perception of resource users provides valuable insights into the condition of reef resources. Ideally, this should be complemented by ecological data on the condition of reefs (e.g. on species diversity and population dynamics) and scientific data on the condition of fisheries (e.g. based on measurement and assessment of CPUE). This would enable validation of local knowledge and perceptions and provide greater certainty on the likely impacts of continued over-fishing and/or improved management, as well as further insights into the vulnerability of reefs to future bleaching events.
- There is scope for improvement in the socio-economic indicators used in this research to measure adaptive capacity. The five sustainable livelihood assets in the SLF provide a

coherent framework for measuring adapting capacity. However, analysis of the results of this study revealed the need for a more precise definition of indicators, to take account of the local context, eliminate duplication, and provide improved coverage of key dimensions of adaptive capacity such as education and participation in decision making.

- The method and frameworks used in this research focus on household livelihood vulnerability to climate change; further research should develop the use of vulnerability indicators focused on issues of gender, governance, power, and institutions as further discussed below.
- Gender, which was not directly captured in this study, should be an important component of future vulnerability studies. For the purpose of this study, heads of households, who were always male, were interviewed. Women in Fiji and Solomon are actively involved in fishing and most of their catch is for subsistence use. A focus on interviewing women fishers in households could shed new light on vulnerability and adaptive capacity, as well as highlighting the social and cultural barriers that prevent women in Fiji and Solomon Islands from fully participating in decision making.
- A consideration of local institutions, governance, organizations and power distribution is crucial in future research on vulnerability. Governments and NGOs, as well as other local institutions such as churches, can play leading roles in assisting communities in addressing vulnerability.
- This study did not look at new opportunities that might arise in the future, for example through the further development of tourism, infrastructure development, and local investment to strengthen existing economic sectors and/or establish new ones. It is important for future research to examine how new opportunities such as these could benefit local communities help shape social and ecological dynamics of coastal livelihoods.
- Such studies should also consider the interaction between economic development and traditional and cultural identity. The results of this study, like those of previous studies, suggest the introduction of the money economy, while benefiting individual households, has eroded traditional social networks within communities. For example, excess catch which was in the past often shared with other family members is now sold because markets—and the need for money—are there. Thus the trade-offs between different types of household and community vulnerability need to be further explored and taken into account by policy makers.
- Last but not least, future vulnerability studies of coastal communities should adopt a holistic approach, taking account of the spatial and temporal heterogeneity of vulnerability and adaptive capacity. This study was limited to assessing vulnerability of local coastal communities to changes in the availability of reef resources. It thus only provides one dimension of vulnerability. The study finds that most fishers are also involved in farming. However, the adaptation measure chosen by households to address one level of vulnerability exposed households and communities to another level of

vulnerability which needs to be looked at in detail. The vulnerability of farming to climate change, like that of fishing, can be expected to increase over time. Future studies should evaluate overall vulnerability and the potential for co-development of adaptation strategies among communities, government and NGOs in response to the evolving challenges of climate change.

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9 Appendix

Appendix A: Household survey questionnaire

Country:	
Interview #:	
Village:	
House Name	
Date:	
Interviewer:	
Interviewee	

Vulnerability Household Surveys

1. Demographic Information

1.1

Age:	Married/Single/Divorced Widow	Sex	Male	Female

1.2. What is the highest level of education that you completed?

1.3. a) Where are you originally from?

This village	Other village in same district	Another village from different district	Another Province	Other (specify)

If from outside the community:

b) How long have you lived in this village? (number of years)

c) Why did you move to this village?

Fishing	Other work	Family and friends	Health/Spiritual
Farming	Other		

1.4 How many people live in your house?

Adult Male:	Adult Female:	Male Children:	Female Children:

Children will be 18 years under

1.5 What is your religion?

1.6 How many religion/denominations in your household?

2. Livelihood

2.1 What jobs do you and other people in your house do that bring in food and money to your house?

Activity	Rank of Importance	# of people	Notes
Fishing			
Gleaning			
Marketing of Marine Products			
Farming			
Cash Crops			
Salaried Employment			
Informal Economic Activities			
Others (specify)			

Total number of occupation_____

2.2 What was your last fortnightly expenditures? List in order of importance

2.3 What other work have you done in the last 5 years?

Occupation	**Main Job**	**Why stop?**	**Could get a similar job now? (y/n)**	**Prefer to current activity? (y/n)**

2.4 Do you have access to credit? Y/N
__through middlemen __through group (cooperative, etc) __revolving fund __directly to financial institutions __family ___shop __other

2.5 Are you presently in debt (more than a week's income?) (Y/N)

3 Material Style of Life

Household Items and Facilities

Generator	Electricity	Air Conditioning	Refrigerator	Electric fan	Brush cutter
TV	DVD	Sky Dish	Radio/Cassette/CD	Iron	Washing Machine

Furniture

Sofa	Table	Cupboard	Drawers	Sideboard	beds

Lightning

Nothing	Kerosene lamp	Candle	Light bulb	Solar
Benzene lamp	Battery lamp			

Transport

Vehicle	Boat with engine	Boat without engine	Canoe	Raft (bilibili)	Horse

Cooking

Firewood	Charcoal	Kerosene	Gas/Electric

Roof Material

Thatch	Metal Sheets		

Wall Material

Block/Cement	Bamboo	Coconut Leaves	Plank Wood	Cement	Plyboard
Metal Sheets					

Floor Material

Dirt/Soil	Bamboo	Coconut leaves	Plank Wood	Cement
Finished (tiles, etc)	Sand			

Sanitation

Flush Toilet	Water Seal	Pit	Stilt	Nothing

Water Access

Piped	Creek	Well	Bore hole	Tank	Others

4. Social Capital

4.1 Are you involved in making community decisions?

No	Passive (eg attending meetings)	Active (eg suggesting changes)

4.2 Are you involved in decisions about marine resource management?

No	Passive (eg attending	Active (eg suggesting

	meetings)	changes)

4.3 Who has the most power in the closing and opening of tabu areas?
4.4 Who influences and has the most power in village decision making for marine resources? Rank in order of influence and power.

	Power
Chiefs	
Church Pastor	
Fisheries Dept	
NGOs	
Turaga ni Koro	
Registered Village Members	
Unregistered Village Members	
Others (please specify)	

4.5 Have you been involved in any community events outside of your family in the last 12 months?

No	Yes	How many?

4.6 Do you belong to any community organizations or committee? If yes go to 4.5

No	Yes	How many?

4.7 Do you belong to any community resource management organization?

No	Yes	How many?

5. Trust

5.1 How much do you trust the following groups of people? (Please Tick)

	Not at all	Distrust more than trust	About half-half	Trust more than distrust	Trust all	Don't know
Village members						
Village leaders						
Religious leaders						
Government officials						
NGO staff						
People from other villages						
Police/Fish warden						

5.2 Who would you turn to for help? (Please Tick)

Who do you turn to for help	Food shortage	Family member is sick	Conflict with other resource users over resource access	Conflict with Resource management committee	Decline in marine resources	Repair and replace fishing gear	School Fees	To learn fishing skills	Breaking tabu
Family									
Neighbours									
Social Organizations									
Chiefs									
Revolving fund									
Financial Institutions									
None									
Other (specify)									

6 Perception of Marine Resources

6.1 How many fish are on the reefs compared to 5 years ago?

Less Now	Same	More Now

6.2 Rank your five most preferred fish or invertebrates and indicate whether you think their availability has increased, decreased or stayed the same over the past 5 years.

For Consumption	Status	Why	For sale	Status	Why
1.	↑ -- ↓			↑ -- ↓	
2.	↑ -- ↓			↑ -- ↓	
3.	↑ -- ↓			↑ -- ↓	
4.	↑ -- ↓			↑ -- ↓	
5.	↑ -- ↓			↑ -- ↓	

6.3 How have you coped with the decrease in your catch?

6.4 What can affect the number of fish on the reef?

6.5 What can be done to increase the number of fish?

7. Marine Resource Dependency

7.1 How long have you been fishing?

7.2. Do you have access to marine resources?

No access	Use rights (not an owner but allowed to use and manage)	Ownership but not exclusive access (some ppl owner cannot exclude)	Ownership with exclusive access (owner ca readily exclude others)
Use Rights (not an owner but allowed to use but no say in its management)			

7.3 Household fish consumption

Type of catch	Number of days you ate last week	Source		
		Caught by household member	Purchased	Exchanged/Given
Reef Finfish				
Pelagic				
Invertebrates				
Canned fish				

8. Gear Use

When you or other household member go fishing, what equipment is involved?

Gear	Rank Importance	Trips/months (Low Season)	Trip/months (High Season)	Own Gear? (Y/N)	# ppl (house/crew)	Description (eg. Net size)
Handline Shallow/Deep						
Longline						
Trolling						
Gill net (small mesh size)						
Gill net (Shark net)						
Small beach seine net						
Hand Spear						
Spear Gun						

Fish Trap						
Explosives/Poison						
Gleaning						
Hawaiian Sling						
Cast Net						
Others						

9. Fishing Effort

9.1 I realize that some days you catch a lot of fish, other days you may not catch many fish. What is your daily catch on a good day? How much is that worth? Same for poor day, average day

	Poor day	Average day	Good day
Catch			
Daily Effort (hrs, traps)			

9.2 Of your catch how much is ____%eaten ___%exchange/given away and ___% sold

9.3 If you caught 20% less fish **all year** what would you do?

Keep fishing the same amount	Fish harder	Fish less	Move locations	Change gear	Leave fishery – where to?

9.4. If you caught 50% less fish **all year** what would you do?

Keep fishing the same amount	Fish harder	Fish less	Move locations	Change gear	Leave fishery – where to?

If keep fishing then for how long?

9.5 How have your household coped with coral bleaching, hurricane or tidal wave that have affected marine resources in the past?

10. Fisheries Management

10.1 Are there places where people can't fish?

E – External ; L-Local; T-Traditional

Management type	Description	E/T/L	Do ppl still fish there?				
			No	Few	Most	All	Seen*

* write # of times seen in the last year

10.2 Do resource users know about where they cannot fish?

No	Few	Most	All

10.3 Has there been any confusion about who manages the area? ___Yes ___No
If yes explain?

10.4 *(If respondent noted that if s/he has seen people breaking these rules)*What did you do after you saw them? (number the sequence if more than one)

Nothing	Report them:	
Participate	To village official	To a fisheries official
Confront them	To an owner	To the police
Tell Friends	Other (specify)	

10.5 If you did not report them why not?

10.6 Do you feel you can change the rules about resource use and management? ___Yes ___No
How?

10.7 Is there a system to deal with any disagreements about management rules? ___Yes ___No

10.8 If yes, how many conflicts are resolved successfully? ___None ___Few___Half ___Most ___All

11. Impacts and Future of Management

11.1 Overall how has the fisheries management affected:

	Very bad.	Slightly bad.	neither	Slightly good.	Very good.	Not sure
i. your livelihood						
ii. the community						
iii. the environment						

11.2 In what way (eg reduced fishing opportunity, strengthen property rights)

11.3 In your opinion has there been any problem with the management?

11.4 Do you think that fisheries management should be maintained or removed? maintained or removed

12. Diversity of crops

12.1 Do you own the land where you are farming now? Y/N

12.2 If you don't own the land what kind of arrangement do you have?

12.3 Rank the different types of crops that you grow and state whether they are for consumption, sale or both.

Crops	For Household Consumption	For Sale	Both
1.			
2.			
3.			
4.			
5.			
6.			
7			
8			

12.4 What major changes have you seen with your farms?

12.5 What do you think has caused this change and when did they occur?

12.6 What would you do if it rained so much and it ruined your crops?

Intensify farming (fertilizer)	Change crop	Change timing of planting	Change location (new garden)	Fallow	Others (specify)

12.7 What would you do if there is no rain and it ruined your crops?

Intensify farming (fertilizer, irrigation)	Change crop	Change timing of planting	Change location (new garden)	Fallow	Others (specify)

Appendix B: Key informant interview questionnaire

Resource User Key Informant Survey

Country_____ Village_____ Date_____

1. Marine Resource Use

a. What are the top 10 preferred marine species that your community sell and consume at home?

Consumed at home	Sell	Market, middleman etc	Price

b. What is the distance to market?

c. When was the last change in the prices of fish?

d. Are some of these species harvested on a seasonal basis?

e. Are these seasonal harvest the same now? Y/N

f. If answer is no please state the reasons and when did they start to experience these changes?

g. What are some of the major changes that you have observed in your fishing ground over the past 5-10 years?

h. What has caused these changes and when did this change occur?

i. Have you and other fishers in the community experienced a decline in your catch? Y/N

j. How have you coped with the decrease in your catch in the past and now?

k. Do you have any specific plan on how you are going to cope and adapt to this change in the next 10 years?

l. If the resources keep decreasing and you do not have a plan, do you see your community to be affected by this and become more vulnerable to changes?

m. Given the knowledge that you have, what were marine resources like in the past (as long as you can remember, use a time line for this) in terms of abundance and diversity?

n. Were there any specific traditional management strategies used? If yes please explain

2. Gear Used

a. Has there been any change in the types of gear that is used now compared to the past? Where possible please list all the gear that has changed and the year they were introduced and the reason and occasion?

b. What has caused the people to change their gear? (eg. Market demand, food preference etc keep this in mind but do not read it out)

3. Tabu

a. Are there any areas closed for fishing?

b. Who was involved in the closing of this area and the reasons for closing it?

c. Is there any management plan for your fishing ground and tabu?

c. Do the community have the ability/authority to enforce these rules? If the answer is no please give reasons. Please state the rules that are able to be enforced and the ones which cannot be enforced.

d. Did the tabu area made fishing more easier or harder and why?

e. What are the main reasons for opening your tabu? List in order of importance You need some SPACE here

f. How long should a tabu be closed before a harvest?

g. How long should a tabu be opened for fishing?

h. How long should a tabu be closed after a harvest?

4. Access Rights

a. Is the sea open for everyone to fish in or are there boundaries that limit access to specific villages?

b. Do all members of this village have equal rights to use the fishing ground that has been demarcated ?

If the answer is no, then why not?

c. Can you fish in the other villages fishing ground as well?

d. Can people from other districts fish in your fishing ground?

e. Who has exclusive rights to your fishing ground?

5. Power and Decision Making

a. Who has the final authority on marine resource use and access:

b. What is the process of making decisions for marine resource use in your village?

c. What is the role of religion (church or belief) in this process?

6. Conflicts

a. Within the past year have people here had conflicts about marine resources?

If so please describe?

____Ownership _____Access _____gear use _____others

b. Was it internal or external? How many?

c. What was the intensity of this conflict? _____verbal _____mild _____violent _____don't know

d. Could the conflict be resolve? How? Please describe the process.

e. How long would it take for these conflicts to be resolved? _____less than a week _____a week to a month _____more than a month

f. Would this conflict resolution function the same way today?

g. How frequent do these conflicts occur and how many?

_____less than a week _____a week to a month _____more than a month

h. Are there mechanisms in the village that resolve these conflicts. If so are they successful (0=not successful, 1=partially successsful (at least half of the conflicts get resolved), 2=mostly successful (3/4 of the conflicts get resolve), successful (100% success))

Mechanism	Success rate	Time take to resolve conflict

7. Presence of Key Infrastructure

Hospitals	Secondary School	Food markets	Bank
Medical Clinics	Piped Water	Pharmacy	Gas Station
Doctors	Sewer Pipes	Guest House	Dentist
Nurses	Sewage Treatment	Public Transport	Telephone
Primary School	Septic Tanks	Hard Top road	Electricity

8. Resource Management

a. Please tell me the history of marine resource management in your community and how it has changed and evolved overtime?

b. How were decisions made?

c. Were they successful in influencing the community to manage their resources? Y/N please state reasons for your answer.

d. What were the reasons for the different management?

e. Were you able to adapt to the new management approach?

f. How effective were the different management at meeting certain food security (access and availability of nutritious food) goals (in the past, now and in the future)

f. What management options do you have inorder to restore marine resources for future generations?

9. Motivation of Resource Use 10 years ago.

a. What was the main motivation for marine resource use in the past? Please state as far as they can remember.

b. What was the main fishing gear that was used in the past?

c. What are the major species being targeted?

d. What are the different types of gear used now? Please rank in order of importance?

e. How accessible are the reefs now compared to the past

10. Religion

a. How many different religious groups or denominations are present in your village?

b. Do you think that the diversity of denominations within your community have affected the management of resources?

c. What is your general understanding on the management of reef resources based on your beliefs? Try and relate it to what the bible says.

11. Diversity of Crops

a. List the different types of crops that are grown in this community and state whether they are seasonal or not?

b. For all the crops that you have listed, state their sensitivity to withstand drought and flood? This will be on a scale from 1 highly sensitive; 2 slightly sensitive; 3 neither; 4 slightly not sensitive; 5 not sensitive (insert simple table? Separate answer for 'drought' and 'flood'? Crop type / sensitivity?)

c. For all the crops please state whether they are important for food or for cash and use the same scale as above: 1 highly important; 2 slightly important; 3 neither; 4 slightly not important; 5 not important

d. How tolerant are these crops to withstand the different seasons? 1 highly tolerant; 2 slightly tolerant; 3 neither; 4 slightly intolerant; 5 highly intolerant

Crop Type	Food	Cash	Sensitivity		Tolerant	
			Drought	Flood	Dry Season	Wet Season

12. Adaptation to Change

Terrestrial

a. How has your community dealt with drought and rainy season in the past?

b. How many drought and flood have you experienced in the past and when was the last one?

c. When did these changes occur?

d. How have you adapted to these changes?

e. Did you get any help from government and NGOs to assist you on this?

f. When is the wet and dry season?

g. What is your water source during dry season and how far is it from the village?

h. Does this water source gets flooded during heavy rain?

Marine

a. How have the community dealt with tidal waves, hurricanes that affect marine resources in the past?

b. How many of these have you experienced in the past and when was the last one?

c. How did you adapt to these events?

d. Did you get any help from government and NGOs to assist you on this?

e. Is there anything else you would like to mention.

Appendix C: Guiding questions for focus group discussions

Focus Group Discussion on Changes in Reef Resource Use and Availability in Melanesia

For focal group discussions on harvest regime, it will be critical to meet with the most experienced fishers in the group. Preferentially invite people who have at minimum 10-20 years fishing experience in that community. Write down the names of all of the participants, ages, and how long they have been fishing from that community. Record sessions with voice recorder.

A. Changes and Drivers of Reef Resource Use in Melanesia

Find out the past and current use of reef resources within households in Melanesia.
What are the major uses of marine resource in the past 30 and current?
What were the targeted species?
What were the gears used?
How accessible were reef resources in the past?
How accessible is it now?
What were the main drivers for reef resource use in the past 30 years?
What are the major changes observed in reef resource use now?
When did these changes begin?
What are the causes of these changes in reef resource use?
Do they consider themselves vulnerable if the trend continues?

How have the households coped or adapted to these changes? Discuss the strengths that they have in adapting or transforming to reef resource use change.
Would the current trend affect their livelihood within the next 10 years?

B. Sources of Resilience, the elements of Adaptive and Transformative Strength

What changes are occurring with respect to reef resource related livelihood?
Has these changes exposed the households to other livelihood options?
With the increase in demand for reef resources and increase in population, are there management strategies within the household to address this?
How are these households coping or adapting to this ongoing change in reef resource use? What strengths do these households have in coping or adapting to this change?

a. What are the sources of household livelihood vulnerability and strengths?
b. What are the sources of community livelihood vulnerability and strength?

What has been the trajectory over time in coping and adapting and whether this will sustain their livelihood in the future?
What are some management options and at which level can this be addressed?

Appendix D: Household post-disaster survey

Post-disaster Household Survey

Name:

Village:

Date:

1. What have you lost? (Tick box)
2. What kind of impacts did the loss have on the household economy?
3. How extensive were the losses on household economy (rank from 1lowest-4 highest)

	Kind of impact on the household economy	Rank (
Life		
House		
Fishing Gear		
Crops		
Others (specify)		

4. For impacts ranked 3or 4 above, what was done to cope?
5. How successful was this measure? (Rank 1 not successful- 5 extremely successful)

Impact	Describe what was done to cope	Rank (1-5)

6. Why did the coping method(s) fail or succeed?

7. What would have been a source of strength for your household to cope with the disaster?

8. Using the adaptive capacity indicators below, please rank importance when marine resource decrease and natural disasters occur. (rank 1 most important)

	Marine resource decrease		Cyclone	
	Before	After	Before	After
MSL				
Occu mobility				
Occu multiplicity				
Human agency				
Access credit				
Debt				
Social capital				
Gear diversity				
Community infrastructure				
Trust				
Capacity to change				

Appendix E: Protocol for downloading thermal data

PROTOCOL FOR DOWNLOADING THERMAL DATA

1. Download (spatially appropriate) cortad data from NOAA
2. Download ncBrowse (to read .nc files) application
3. Open ncBrowse.exe interface

Files refer to specific latitude/longitude combination:

- Fiji sites (cortad 4,15)
  Muiavuso – 178.364, -18.149
  Ovalau – 178.829, -17.736
  Koro – 179.436, 17.349
  Kia – 179.046, -16.204

- Solomon Island sites (cortad 4,14)
  Nusa Hope – 157.467, -8.275
  Lokuru – 157.359, -8.604
  Munda – 157.243, -8.350
  Raromana – 157.004, -8.213

4. Click File, select Open File and select "cortad row 4 column 15.nc"
5. Click File, select Export variable to cdl (ctrl-E)
6. Select TSA_DHW

First date for lat/long combination is 03.11.1981, final data is 31.12.2010

Thus, select time periods:

03.11.1981 – 31.12.1990
01.01.1991 – 31.12.2000
01.01.2001 – 31.12.2010

7. Enter date range (start and end) the first of the three time periods
8. Deselect "Use Range" for lat and long and enter specific values for Muiavuso
9. Click Export Variable, and save .cdl file
10. Repeat steps 5-9 for the all Fijian sites throughout all three time periods
11. Then, Click File, selection Open File and select "cortad row 4 column 14.nc" and repeat steps 5-9 for all Solomon Island sites throughout all three time periods
12. Open the first delimited .cdl file in Excel, scan through to check coordinates
13. Scan to the bottom of the file to locate each week's DHW value – average these values

Appendix F: Taro leaves eaten by caterpillar after the cyclone in Tuatua, Fiji

Appendix G: Partly damaged church in the community of Tuatua

Appendix H: Make shift houses after the cyclone

Figure A 1: Principal component analysis of the 11 social adaptive capacity indicator analysed at an aggregate community level for Fiji

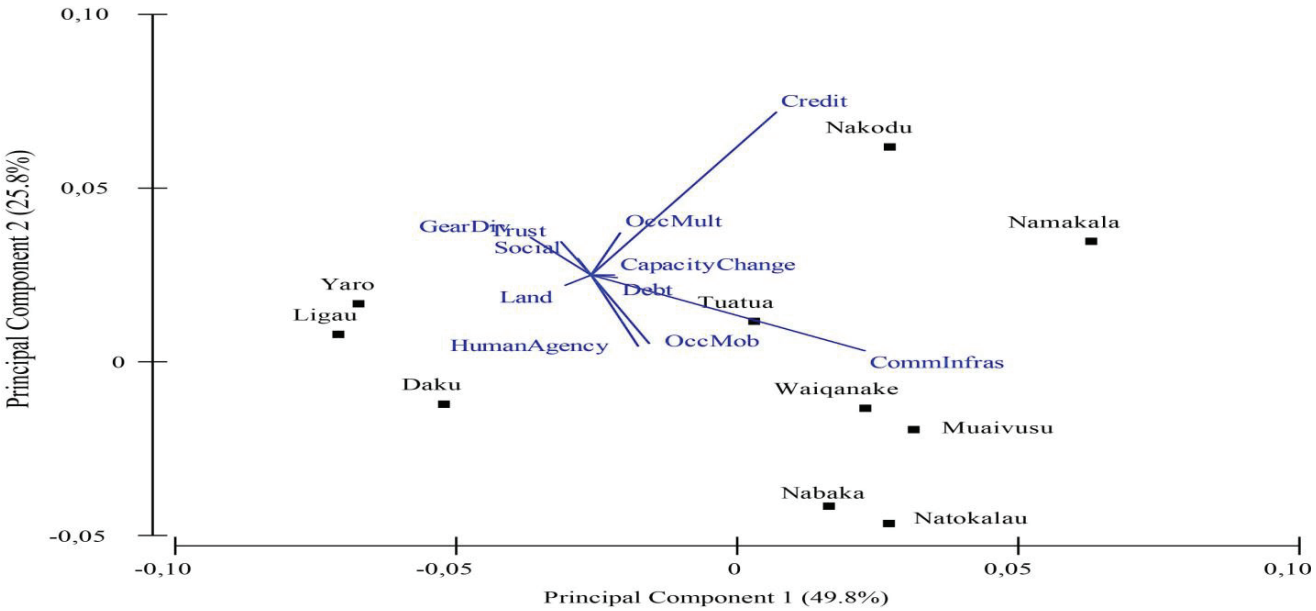


Figure A 2: Principal component analysis of the 11 social adaptive capacity indicator analysed at an aggregate community level for Solomon Islands

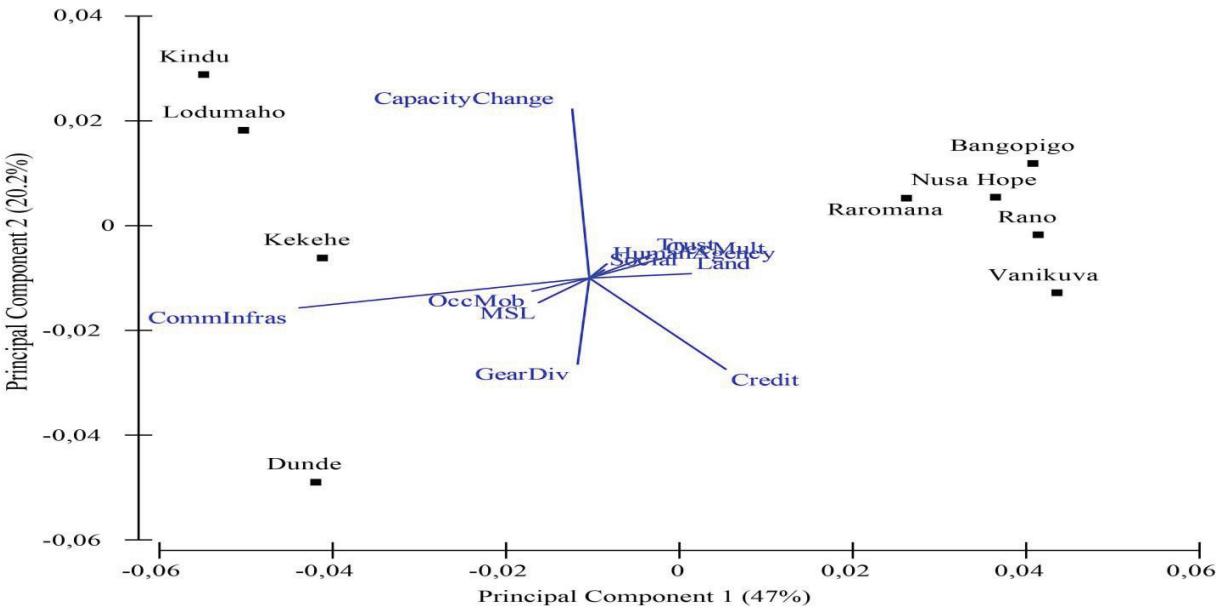
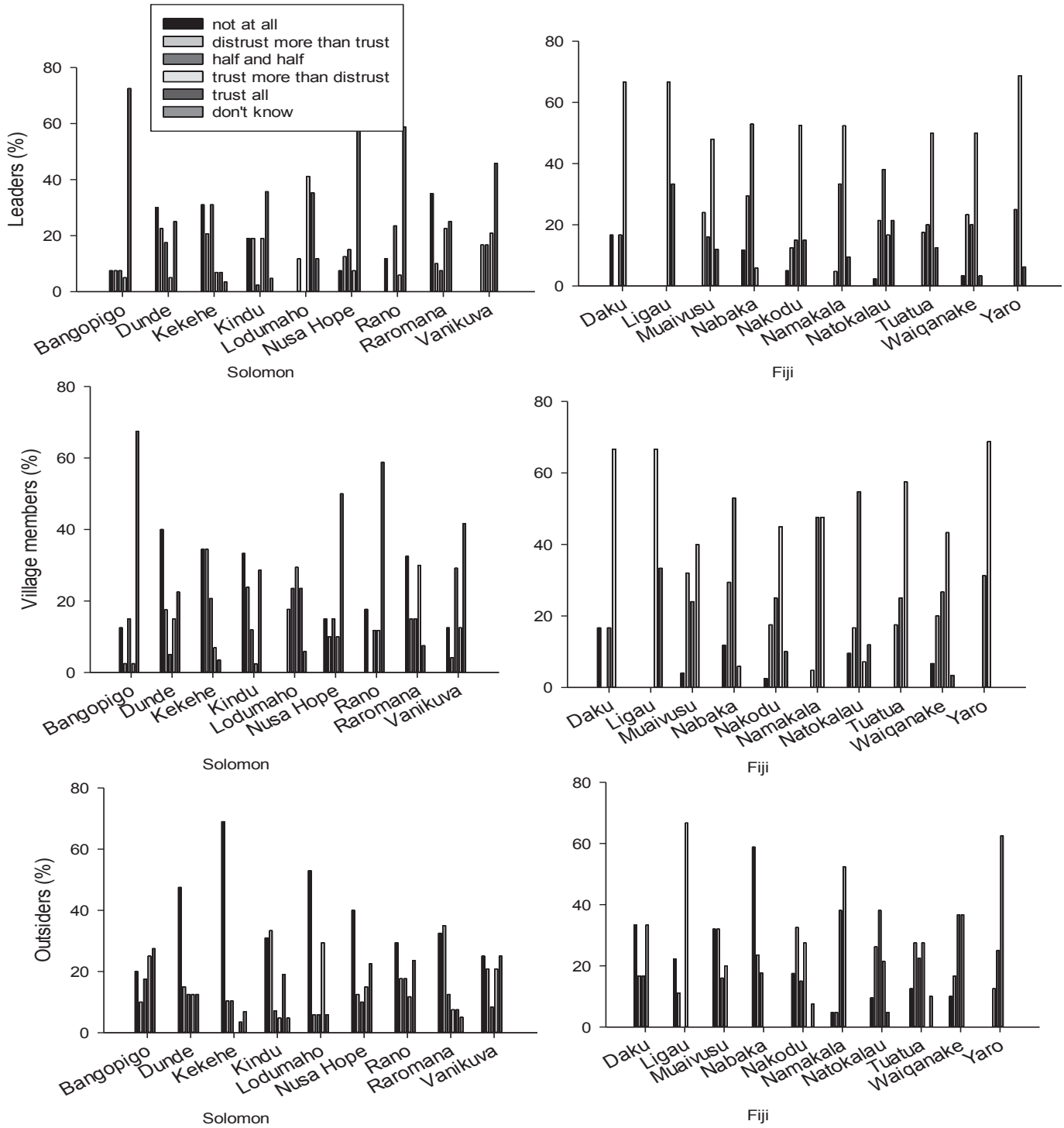
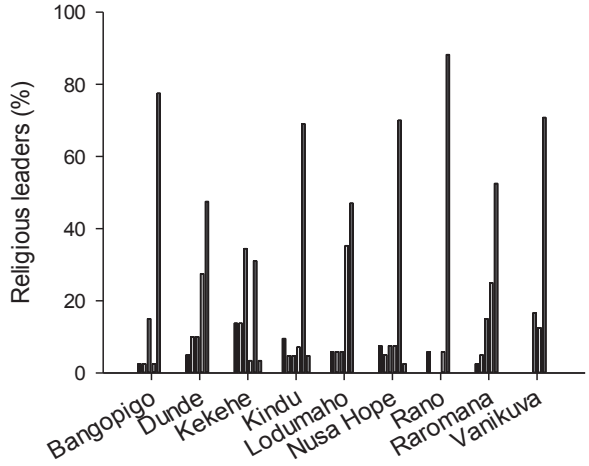
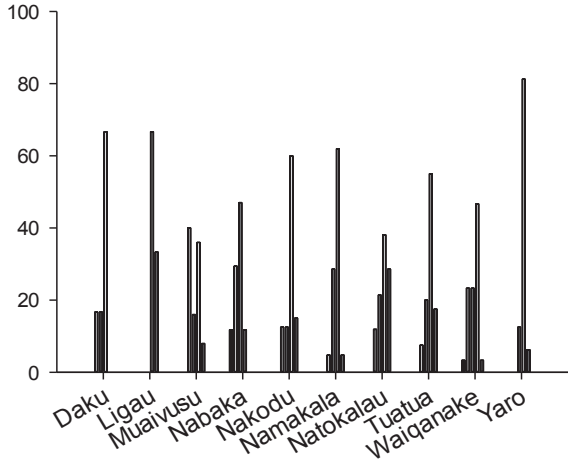


Figure A3: The level of trust of households on leaders, village members, outsiders, religious leaders, government and NGO for Fiji and Solomon Islands

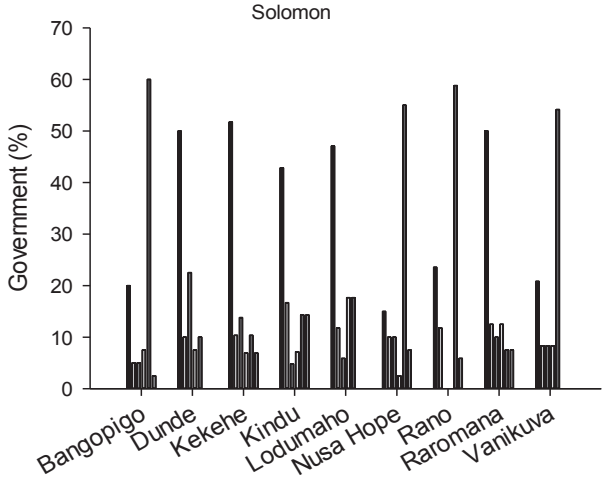




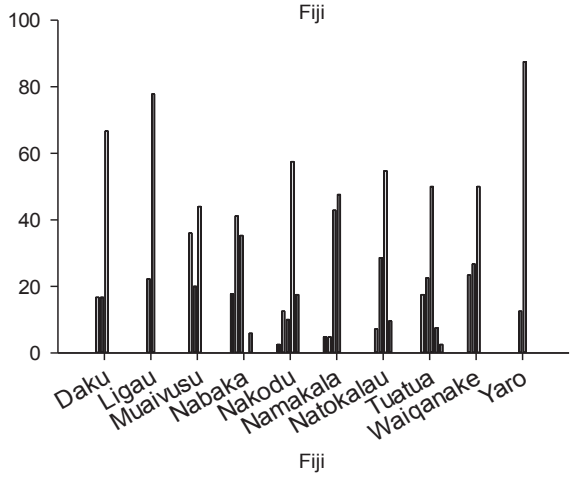
Solomon



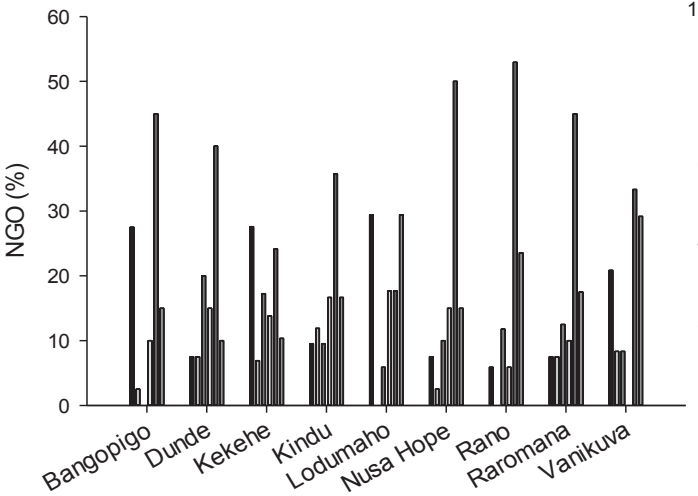
Fiji



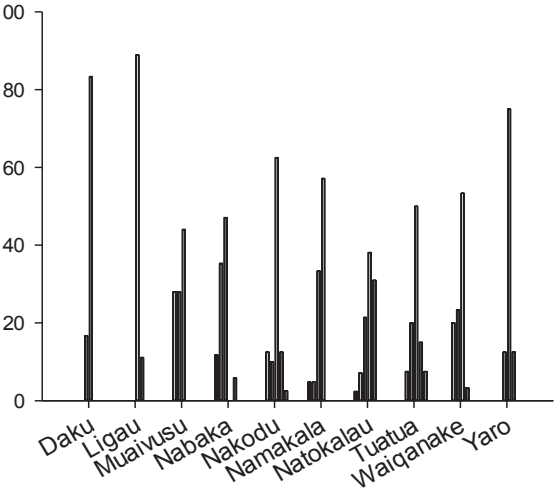
Solomon



Fiji



Solomon



Fiji

Table A 1: Table showing the total variance and the loadings of the loadings of the adaptive capacity indicators for Fiji

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,436	31,234	31,234	3,436	31,234	31,234	2,863	26,024	26,024
2	2,500	22,724	53,958	2,500	22,724	53,958	2,436	22,143	48,166
3	1,789	16,268	70,225	1,789	16,268	70,225	2,426	22,059	70,225
4	1,280	11,638	81,864						
5	1,175	10,684	92,548						
6	,639	5,808	98,355						
7	,116	1,059	99,414						
8	,045	,406	99,820						
9	,020	,180	100,000						
10	1,826E-16	1,660E-15	100,000						
11	-7,551E-17	-6,864E-16	100,000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
TRUST	-,836	,161	,452
CREDIT	,824	,488	,149
human agency	,736	-,327	,103
SOCIAL	-,654		,543
GEARDIVE	-,621	,248	,225
DEBT	,577	,250	,524
OCCMULTI	-,128	,844	-,447
INFRASTR	,101	,794	
LAND		-,709	-,273
occupational mobility	,563		,700
CCHANGE	,150	,395	-,408

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Table A 2: Table showing the total variance and the loadings of the loadings of the adaptive capacity indicators for Solomon Islands

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5,175	47,047	47,047	5,175	47,047	47,047	4,579	41,628	41,628
2	2,222	20,200	67,248	2,222	20,200	67,248	2,685	24,411	66,039
3	1,546	14,056	81,303	1,546	14,056	81,303	1,679	15,264	81,303
4	,951	8,649	89,953						
5	,563	5,120	95,073						
6	,360	3,270	98,343						
7	,155	1,407	99,750						
8	,028	,250	100,000						
9	3,645E-16	3,314E-15	100,000						
10	-6,459E-17	-5,872E-16	100,000						
11	-2,192E-16	-1,993E-15	100,000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component		
	1	2	3
CREDIT	-,940	-,119	
LAND	,892		-,239
TRUST	,870	,305	,276
OCCMOB	-,847		-,138
OCCMULTI	,838	,174	
MSL	-,702	,512	
INFRASTR	,588		-,488
GEARDIVE	-,271	,864	-,334
SOCIAL	,448	,697	,490
HAGENCY	,455	-,664	-,206
CCHANGE		-,366	,860

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Table A 3: The frequency and percentage of households in Fiji and Solomon Islands that were actively or passively involved in community decision making

Country	Participation	Frequency	Percentage
Fiji	Active	129	52.4
	Passive	109	44.3
	No	8	3.3
	Total	246	100
Solomon Is	Active	75	26
	Passive	39	13.5
	No	175	60.6
	Total	289	100

Table A 4: The frequency and percentage of households in Fiji and Solomon Islands that were actively or passively involved in marine resource decision

Country	Participation	Frequency	Percentage
Fiji	Active	69	28
	Passive	63	25.6
	No	114	46.3
	Total	246	100
Solomon Is	Active	42	14.5
	Passive	16	5.5
	No	231	79.9
	Total	289	100

Table A5: The average occupation per household for Fiji and Solomon Islands and also for the different communities

Country	Community	Average Occupation	Standard Error
Fiji	Daku	2.166667	0.884715
	Ligau	2.444444	0.814815
	Muaivusu	2.84	0.568
	Nabaka	2.764706	0.670557
	Nakodu	3.5	0.55336
	Namakala	2.857143	0.623422
	Natokalau	2.119048	0.326963
	Tuatua	2.875	0.454545
	Waiqanake	2.866667	0.523401
	Yaro	2.4375	0.609375
	Total	**2.687**	**1.713**
Solomon Is	Bangopigo	4.175	0.660079
	Dunde	3.125	0.494071
	Kekehe	2.689655	0.499472
	Kindu	3.309524	0.51065
	Lodumaho	3.117647	0.75616
	Nusa Hope	4.175	0.660079
	Rano	3.705882	0.898832
	Raromana	4.15	0.656126
	Vanikuva	3.708333	0.756957
	Total	**3.572**	**1.89**

Table A 6a: PCA on respondents' responses regarding their perception of what could increase the number of fish in Fiji

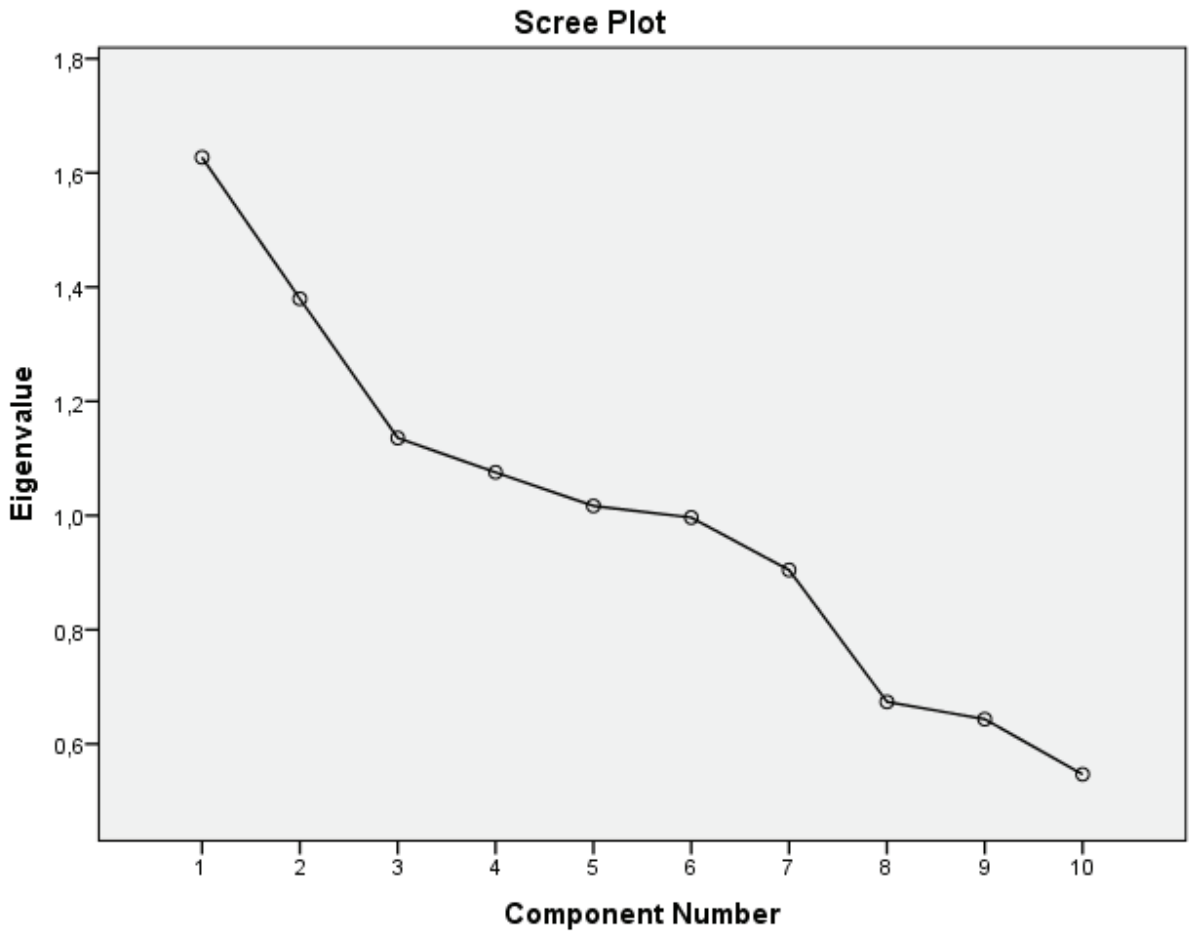
Component Matrix[a,b]

	Component		
	1	2	3
ban/reduce use of nets	,763		
ban traditional fishing	,669		
awareness and education	,492		
ban rubbish on shore		,829	
stop poachers		,675	
ban night diving		,446	
establish tabu areas			,602
ban catching undersized fish	,475		,479
coral planting			-,459
ban overharvesting			

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

b. Only cases for which County = Fiji are used in the analysis phase.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Eigenvalue
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1,4
1,2
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0,8
0,6
1
2
3
4
5
6
7
8
9
10
Component Number

Table A 6b: PCA on respondents' responses regarding their perception of what could increase the number of fish in Solomon Islands

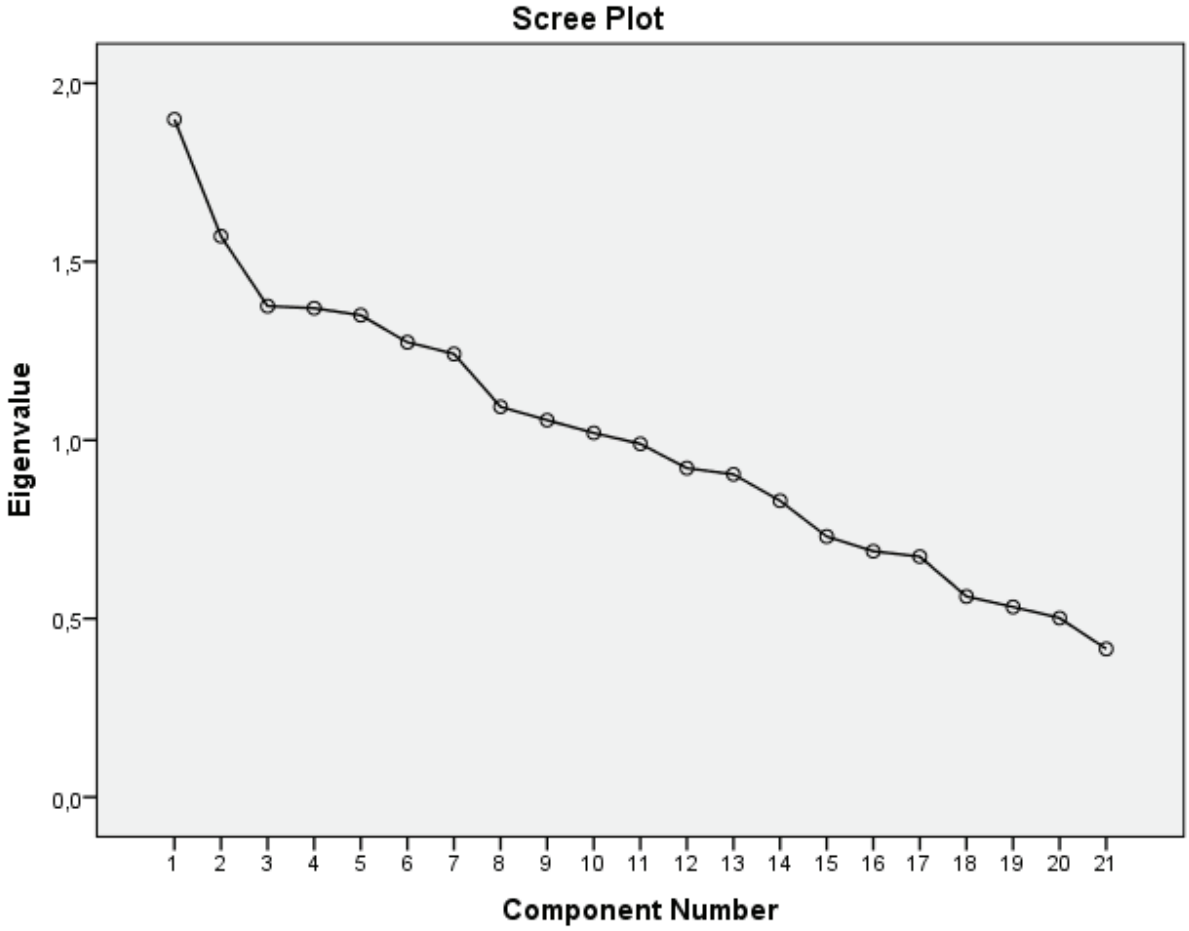
Component Matrix[a,b]

	Component		
	1	2	3
establish tabu areas	-,669		
fish less	,618		
stop fishing			
ban use of shore as toilet			
stop poachers			
enforce tabu rules			
pig pen move inland			
ban harvesting of bech-de-mer		,635	
fish for deep sea fish		,527	
ban night diving		-,509	
ban/reduce use of nets		-,455	
alternative income source			
ban overharvesting			,530
coral planting			,423
awareness and education			
ban rubbish on shore			
catch big fish only			
ban harevsting corals			
ban traditional fishing			
stop logging			
ban catching undersized fish			

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

b. Only cases for which County = Solomon are used in the analysis phase.


Scree Plot
Eigenvalue
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1,5
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0,0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Component Number