PACC TECHNICAL REPORT 4

JUNE 2014

Vulnerability and adaptation (V&A) assessment for Ontong Java Atoll, Solomon Islands

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This report is an output of the Solomon Islands PACC Project. It was written by Paul Marita and Derrick Manuari, with contributions from Jasper Bonie and Casper S. Sikou. The report was reviewed by a team that included Netatua Pelesikoti and Peniamina Leavai (SPREP), Ilisapeci Masivesi (Australian Department of Foreign Affairs and Trade), Gabor Vereczi and Marta Moneo (UNDP), and the coordinators of the PACC food security projects.

EXECUTIVE SUMMARY

The low-lying atolls of Ontong Java have been identified as particularly vulnerable to climate change. Remote from the country's urban centres, their fragile food systems are threatened by sea level rise, high tides, and extreme climate events. These atolls were therefore selected as the site for a pilot project under the Pacific Adaptation to Climate Change (PACC) programme.

As a first step, a vulnerability and adaptation (V&A) assessment was carried out in Ontong Java Atoll in May 2011. The assessment focused on five key areas: agriculture, food security, land degradation, forestry, and biodiversity; human settlements and health; water resources and freshwater ecosystems; energy, industry, commerce, and financial services; and coastal zone and marine ecosystems.

The assessment carried out a situational analysis of the human and natural systems on the atolls, the current climate and sea level, and projections of climate and sea levels into the future. Data on people's perceptions of their vulnerabilities and their coping capacities were then gathered through household surveys, community workshops and informal interviews in the two main communities of Luaniua and Pelau.

The main staple crop grown on the islands is swamp taro, which provides most of the islanders' food. Poor soils, poor soil management and lack of knowledge about and access to suitable crop varieties are among the reasons limiting the planting of alternative crops. Subsistence farming is supplemented by buying of imported food such as rice and cassava, which come by boat from Honiara. The main commercial activity, and main income source, is harvesting and selling of bêche-de-mer. However, over-harvesting has greatly depleted these marine resources and the government has placed a ban on their collection. This has contributed to financial hardship and food insecurity.

All the people who were interviewed reported a perceived increase in the frequency of natural hazards. It was also found that people perceive the most vulnerable sectors to be water and food supply.

Improving agriculture on Ontong Java should include introducing and promoting mixed multiple cropping and agroforestry (atoll permaculture); the identification and use of salt-tolerant crops and disease-resistant, quick-maturing crops (cassava, fruits and nuts); the use of raised beds as a safeguard against saline soils; proper preservation of seeds for future farming seasons; the use of organic manure instead of chemical fertilisers; and pest and disease control and quarantine. Improving the soils should be given high priority. Government initiatives such as improving transportation and offering transport subsidies will also be important so that food can be brought from Honiara.

The following are recommendations for actions that will contribute to climate change adaptation and risk reduction for communities in Ontong Java.

In the short term:

- Set up a community-based climate change adaptation and disaster risk management committee for Ontong Java Atoll, recognising the partnership and role of church-based and community-based organisations such as mother's union, chiefs and other community leaders.
- Offer a study or look and learn visit to other Pacific island countries and leading institutions to learn about issues such as crops suitable for the atoll environment (including salt-tolerant crops) and water management systems and practices.
- Supply water tanks to the communities to address water shortages.
- Authorities should require environmental and social impact assessments as a precondition for approval of projects in the identified vulnerable sectors.
- New initiatives addressing food security should build on the existing foundation set up by the Anglican Church of Melanesia (ACOM) climate change network, and be carried out in partnership with Malaita National Disaster Management Office (NDMO).

- Install meteorological instruments to collect data on rainfall, and use to assist planning by local farmers on when and where to plant their crops.

In the medium term:

- Undertake demonstration activities in the communities of Pelau and Luaniua to improve food production through modifying the soil and food production environment. Measures should include: improved composting techniques; agroforestry; growing vegetables in raised beds and containers; improved home gardening techniques; establishing small nurseries for high quality planting materials; and the introduction of 'soil schools'.
- Advocacy and education on climate change and its impacts on people, livelihoods, and the environment.
- Develop and implement new farming methods, and identify and trial new crop varieties and other drought- and salt-tolerant plants and trees that can be used by communities.
- Improve communication to enhance flow of information especially between Honiara and the Atoll. Work with telecommunication companies like Solomon Telekom and Bemobile to expand their services to the two main islands of Ontong Java, to improve early warnings and information dissemination during natural hazards.
- Train and build capacity of multi-sectoral teams who can make regular visits to the islands to carry out assessments, awareness raising and other services.
- Run financial literacy and resource management courses in Ontong Java to enable communities to better manage their money and other resources.

In the longer term:

- Specialised training for identified Ontong Java individuals about climate change vulnerability and adaptation issues, including ecosystem-based adaptation options. Studies and training should be coordinated with the Climate Change Division within the Ministry of Environment, Conservation and Meteorology and involve training institutions such as Solomon Islands College of Higher Education (SICHE) through its School of Natural Resources Programme and Rural Training Centres, and NGOs such as Kastom Gaden.
- Promote traditional practices, including agroforestry and food preservation methods.
- Put in place sound biosecurity policy, plans and strategies to control the introduction of new species, and restrict and deal with the movement and proper disposal of invasive species on the islands.
- Encourage voluntary migration through practical means such as the provision of scholarships for young people to relocate for study.
- Commence studies and planning for relocation of communities. This must be done in open consultation with the people of Ontong Java.

ABBREVIATIONS

ACOM	Anglican Church of Melanesia
EDA	Eastern Development Agency
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization (of the UN)
GCM	General circulation model
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
MAL	Ministry of Agriculture and Livestock
MECM	Ministry of Environment Conservation and Meteorology
MECDM	Ministry of Environment, Climate Change, Meteorology and Disaster Management
NDMO	National Disaster Management Office
NGO	Non-governmental organisation
PACC	Pacific Adaptation to Climate Change [programme]
PACCSAP	Pacific-Australia Climate Change Science and Adaptation Planning
PMU	Project Management Unit [PACC]
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and adaptation [assessment]

1. INTRODUCTION

The PACC programme is the largest climate change adaptation initiative in the Pacific region, with projects in 14 countries and territories. PACC has three main areas of activity: practical demonstrations of adaptation measures; driving the mainstreaming of climate risks into national development planning and activities; and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. The programme began in 2009 and is scheduled to end in December 2014.

The Solomon Islands National Adaptation Programme of Action (2008) highlighted agriculture and food security as one of the key priority areas which are vulnerable to the impacts of climate change, and highly recommended for adaptation interventions. The low-lying atolls of Ontong Java have been identified as particularly vulnerable to climate change. Remote from the country's urban centres, their fragile food systems are threatened by sea level rise, high tides, and extreme climate events.

The following criteria were used to select the priority focus area for the Solomon Islands PACC project: (a) a strong fit/alignment with existing programmes; (b) necessary baseline assessments carried out, and activities ready for implementation; (c) co-financing available. Based on these criteria and on stakeholder consultations, food production and food security was selected as the priority focus area, and Ontong Java Atoll was identified as the site for the first demonstration project (PACC Solomon Islands, 2009).

As a first step, to identify adaptation interventions, a vulnerability and adaptation (V&A) assessment was carried out in Ontong Java Atoll in May 2011. The assessment team included the Eastern Development Agency (EDA) as lead agency, the PACC Project Management Unit (PMU), the Ministry of Agriculture and Livestock (MAL) as implementing agency, and the Ministry of Environment Conservation and Meteorology (MECM) as Focal Point Ministry.

'Vulnerability and adaptation assessment' is a broad term that includes a variety of methodologies which share the aim of identifying and understanding the potential impacts of climate change and options for adaptation. The approach followed in this V&A assessment is based on the procedure outlined in Nakalevu (2006). Key to this approach is keeping the community at the centre, and using the process itself to empower the community to increase its own adaptive capacity. Climate science and modelling, and social science, are also an important part of the process, but these complement the community-based starting point, rather than leading the way.

DEFINITIONS AND ISSUES

VULNERABILITY

The IPCC defines vulnerability as "the extent to which climate change may damage or harm a system", adding that vulnerability "depends not only on a system's sensitivity but also on its ability to adapt to new climatic conditions". A highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained (Watson et al., in IPCC (2000)).

Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity. Vulnerability can be classified as low, medium, high and critical.

ADAPTATION

The IPCC defines adaptation as "the degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous, or planned, and can be carried out in response to or in anticipation of changes in conditions" (IPCC, 1997). Adaptive capacity is therefore the ability of a system or people to adjust to given situations, including climate change, "to moderate potential damages, to take advantage of opportunities or to cope with the consequences"[1].

FOOD SECURITY

The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. In many countries, health problems related to dietary excess are an increasing threat.

Food security is built on three pillars:

- Food availability: sufficient quantities of food available on a consistent basis;
- Food access: having sufficient resources to obtain appropriate foods for a nutritious diet;
- Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

1 Natcom (date unknown). "Vulnerability Assessment and Adaptation due to Climate Change: India's Initial Communication to the UNFCCC", Ministry of Environment and Forests, Government of India.

2. BACKGROUND

Global warming due to increased greenhouse gas concentrations has become a reality and is having detrimental effects. It is causing increased climate variability, including changed frequency and intensity of extreme weather events, and impacts include sea level rise, coastal flooding, coastal erosion, inundation and saltwater intrusion. These hazards pose a threat to our communities. As stated during the 2nd UNFCCC conference in 1990, "Climate change issues reach far beyond atmospheric and oceanic sciences, affecting every aspect of life on this planet. The issues are increasingly pivotal in determining future environmental and economic well-being. Climatic variations have profound effects on natural and managed systems; the economies of nations and the well being of people everywhere".

Despite the universal awareness of global warming and climate change, in many parts of the world there is a lack of localised knowledge about climate change and its implications for issues such as food security. In Solomon Islands, for instance, there is a lack of empirical data on the climate and climate change, and impacts on the islands' inhabitants, coupled with a lack of technical and analytical capability. Hence people have been largely ignorant of the adverse effects of climate change until recently (Hiriasi, 2007).

There is a wide diversity of social and biophysical environments within Solomon Islands, and some systems are likely to be particularly sensitive to climate change and sea level rise. Those identified as being of greatest sensitivity are: (1) subsistence and commercial agriculture; (2) human health; (3) coastal environments and systems; (4) water resources; and (5) marine resources. Vulnerability of these sectors is affected by factors such as geography, as well as the socio-economic and political context of Solomon Islands. Ontong Java, for example, is low-lying and therefore vulnerable to events such as king tides and high swells. This also affects, for example, soil fertility and land use. The pressure from a rapidly increasing population is exacerbating the situation as exploitation of resources is rapidly increasing. In rural areas, especially remote islands such as Ontong Java, access to basic services such as medical services, water and sanitation, education, telecommunications and transportation is difficult. All of these factors contribute to the degree of vulnerability.

This V&A assessment provides a synthesis of the current state of knowledge about the vulnerability to climate change of the people and communities of Ontong Java atolls. More importantly, it identifies the gaps and priority needs that are essential to our understanding of Solomon Islands' vulnerability to climate and sea level change, and for effective adaptation.

The Ontong Java islanders have coping mechanisms for extreme events, such as traditional methods of food preservation. They have relied on copra production and harvesting of marine resources such as trochus and bêche-de-mer for income. The money earned from the harvest of their resources has always been a fallback in times of disasters so it has been rare that the islanders sought assistance from the government in the past. However, these marine resources are becoming seriously depleted due to increasing demand from an increasing population and the shift from a subsistence to a cash economy. The government has therefore had to put a ban on bêche-de-mer harvesting.

Food supply and availability are a critical component of the communities' vulnerability and coping capacity. People have depended on traditional farming, preparation and storage methods to survive. However, traditional farming methods are now being seriously challenged, due to a range of factors including poor usage of limited agricultural land, changing conditions such as increasing saltwater intrusion, coastal erosion, sea level rise and changing rainfall regimes, increasing dependence on imported food, and social change which leads to a general erosion of traditional practices. Many garden sites that have been used for centuries are now abandoned as the sea erodes the coastal regions and infiltrates low-lying locations. People are moving to other sites to make gardens, but most of these new locations have sandy soils which are not suitable for food plants such as swamp taro. There are very limited crop varieties that can grow in these soil conditions. With increasing dependence on imported goods, Honiara is an important source of food; however, shipping services are not always reliable.

For many years people have depended on underground water for drinking and household use, including gardening. Today, with rising sea levels, this water is becoming saline and no longer drinkable. People now depend on rainwater collected in water tanks as well as natural coconut water. However, not all families have water tanks and even coconuts are becoming less available. Hence, water security is also an important issue for the people of Ontong Java.

2.1. Natural and human systems of Ontong Java Atoll

Ontong Java Atoll comprises the most northern islands of the Solomon Islands (Figure 1). There are 122 small islands or islets comprising the atoll, with the highest point of land just 3 to 4 metres above sea level. The islands are located at latitudes 5 to 12 degrees and between longitudes 143 and 168 degrees. The atoll covers an area of 1,400 km^2 with 12 km^2 of land. The diameter is 50 km, making it one of the largest atolls in the world. Two islands are permanently inhabited – Luaniua and Pelau. Several others are used by the villagers as temporary homes while they are on fishing trips. There are 23 passages through the atoll reef.

2.1.1. Vegetation

The natural vegetation includes *Scaevola taccada*, *Terminalia samoensis* and *Pandanus tectorius* on the small sand and shingle cays; *Brugaiera gymnorrhiza* mangrove in the tidally inundated depressions inside annular cays and islets; and broadleaf woodland dominated by *Pisonia grandis* in the interior of the large islets. The vegetation of almost all the Ontong Java islands has been drastically altered by human occupation, and coconut plantation or woodland is now the overwhelmingly dominant vegetation type.

2.1.2. The marine ecosystem

The lagoon on Ontong Java Atoll is located at the centre of the ring of atoll islands. Coral reefs are found within the lagoon, and the reef type depends on the depth of water in the lagoon. Table 1 describes the reef types found at each depth level.

Table 1. Reef types found in Ontong Java lagoon (modified from Crean (undated)).

Water depth (metres)	Reef type
1–2	**Shallow reef flat:** Influenced strongly by tides, characterised by scattered coral colonies (usually dead). Fragments of dead coral litter the reef surface, mainly sand or debris/sand. Water contains suspended material. Current strong and variable.
2–6	**Reef flat:** Not strongly influenced by tides. Live coral formation scattered on a predominantly coralline sandy bottom.
6–25	**Reef slope:** Gradient variable. Steep slope – basically a coral face. Gentle slope: Scattered coral formations on a coralline sand bottom.
6–30	**Reef shallows:** Emergent reef area usually between 20–25 metres deep, scattered coral formations. Reef visible from surface.
30–46	**Lagoon floor:** Substrate unconsolidated, comprising coral chips and sand. Absence of coral structures or colonies.

The animal resources of the atoll islands are limited, but those of the productive reef are abundant. These areas provide the main fishing grounds for sea bream (*Sparus* spp.), trevally (*Carangidae*), emperors (*Lethrinus* spp.) and barracuda (*Agrioposphyraena barracuda*). Tridacna clams, cuttlefish and octopus are common inhabitants of the coral reefs in shallow water. Four species of turtle are found within the lagoon – green (*Chelonia mydas*), hawksbill (*Eretmochelys imbrlcata*), leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*). The green turtle is a regular item in the diet of the local people.

2.1.3. People and land systems

The people of Ontong Java are of Polynesian descent. The two permanently inhabited islands, Luaniua and Pelau, were chosen by the arriving Polynesians because of the fertile soil suitable for growing crops.

Luaniua Island is located in the southeast of the atoll chain and contains the atoll's largest village. It is the most populated island with a total population of 2,057 (Solomon Islands National Population Census, 2009). Luaniua Island has five tribes and 13 chiefs. There are six trading stores and an anchorage for ships. The boat trip from Honiara takes two days.

Pelau Island is the second most populated island in the group. It is located in the northeast of the atoll, and has a population of 800 (Solomon Islands National Population Census, 2009). The island has one chief.

There are two land systems in Ontong Java, called *Lomousa* and *Pusaraghi*. The *Lomousa* system consists of deep, freely draining coral and mineral sand soils (Hansell and Wall, 1976). This soil type is used for agriculture, but only coconuts thrive well and in abundance. Limiting factors include soil salinity, rockiness, and coarse texture. The *Pusaraghi* system consists of poorly drained peat and alluvium soils, and is found mostly at the back of the islands about 15 metres from the shoreline. According to MECM assessments, these soils are contaminated with salt due to infiltration of seawater, and this is currently causing harm to the swamp taro crop.

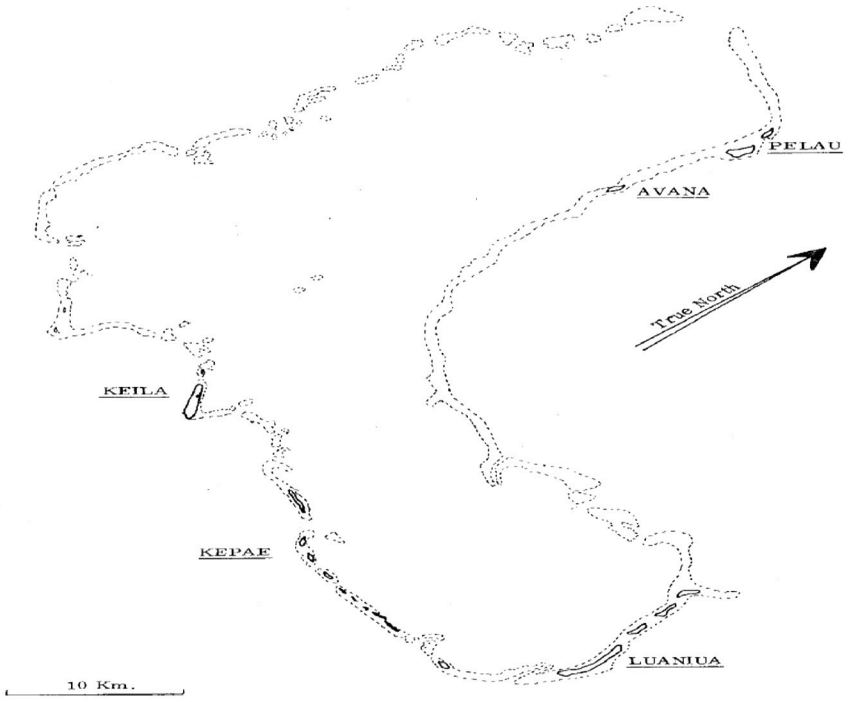


Figure 1. Map of Ontong Java Atoll. (Source: Crean (undated).)

2.2. Current climate and sea level

2.2.1. Temperature and rainfall

Solomon Islands has two seasons, a wet season from November to April and a dry season which usually falls between May and October (Figure 2). It is usually hotter in the dry season and cooler in the wet season. In Honiara since 1951, the annual maximum and minimum temperatures have increased (Figure 3). Maximum temperatures have increased at a rate of 0.15°C per decade since 1951, consistent with the global pattern of warming (PACCSAP, 2010).

Solomon Islands has already experienced long-term changes in climate over the last 30–100 years (Trenberth et al., 2007). The annual mean surface temperature, for instance, has increased by between 0.5 and 0.8°C through the period 1901 to 2005, with an increase of between 0.15 and 0.25°C per decade since 1979. This is consistent with the entire tropical western Pacific region and the near-surface temperature observations from Fiji, showing higher than normal temperatures in the years 2003–2006, along with a significant increase in the numbers of both hot days and hot nights (Mataki et al., 2007). Analysis of temperature data at four synoptic stations on the Solomon Islands also reveals an increase in the near-surface temperature in recent years (Rasmussen et al., 2009).

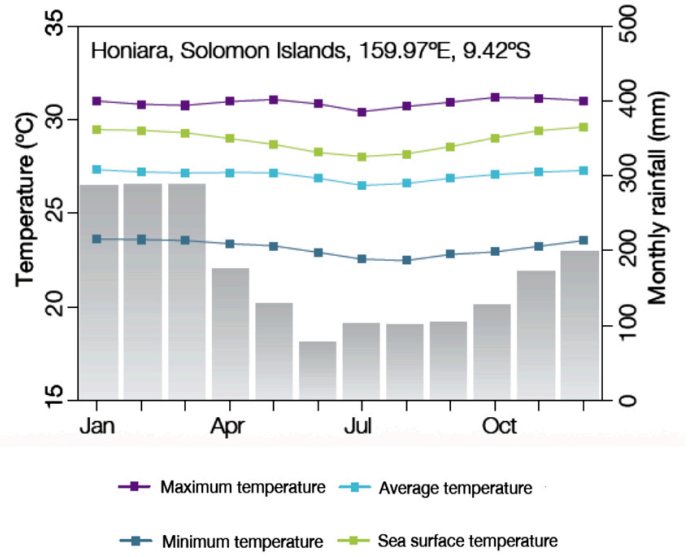


Figure 2. Seasonal temperature and rainfall in Honiara. (Source: PACCSAP Program, http://www.pacificclimatechangescience.org/)

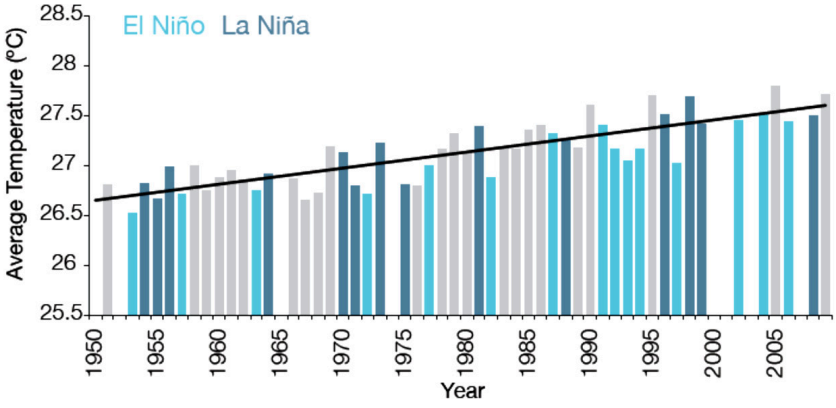


Figure 3. Average annual temperatures for Honiara. Light blue bars indicate El Niño years, dark blue bars La Niña years, and grey bars neutral years. (Source: PACCSAP Program, http://www.pacificclimatechangescience.org/)

There is a lack of data on rainfall for Ontong Java Atoll. However, by talking to the people on the atolls and analysing data for Honiara (Figure 4), and nearby regions, particularly Auki in Malaita (Figure 5), it is known that rainfall distribution varies throughout the year. The annual rainfall is always high, with a lot of rain in the months of January, February, March, April, May, October, November and December. The months of May, June, July and August usually have a moderate average temperature. On average, the warmest month is January and the coolest month is August. March is the wettest month, while August is the driest month.

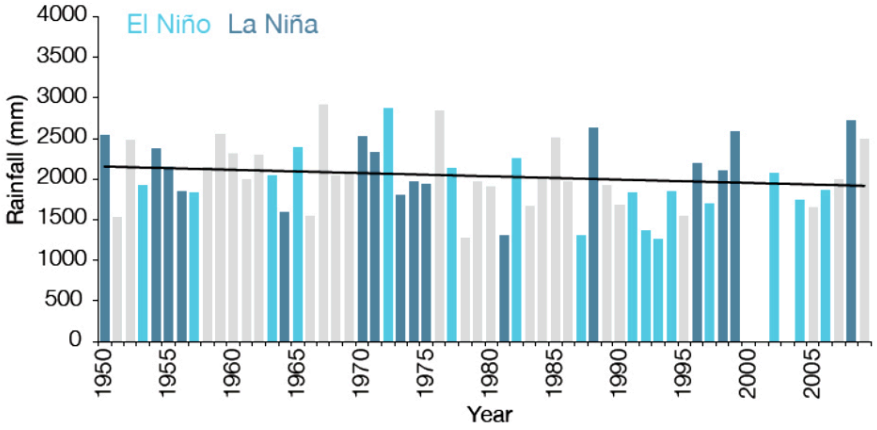


Figure 4. Annual rainfall for Honiara. Light blue bars indicate El Niño years, dark blue bars La Niña years, and grey bars neutral years. (Source: PACCASP Program, http://www.pacificclimatechangescience.org/)

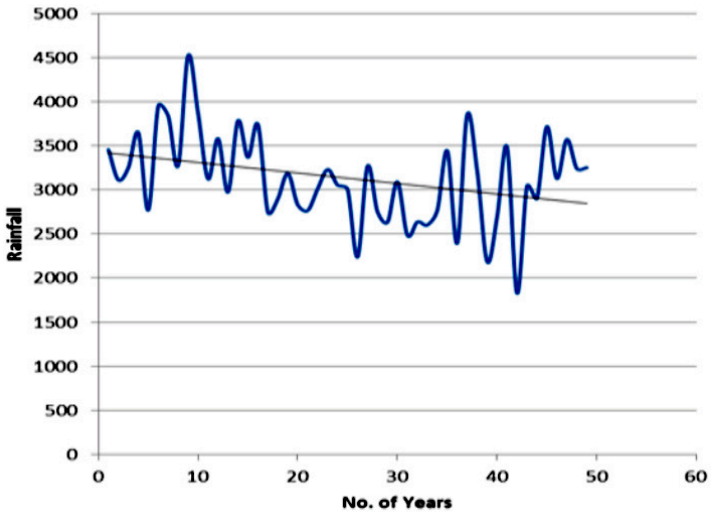


Figure 5. Annual rainfall trend of Auki, Malaita Province. (Source: Solomon Islands Meteorological Services.)

2.2.2. Extreme events

Solomon Islands is susceptible to natural disasters, including tropical cyclones and storms. Between 1969/1970 and 2004/2005 an average of 1.4 tropical cyclones per year were experienced (Rasmussen et al., 2009; Figure 6). However, according to scientific records over the last approximately 50 years, Ontong Java has rarely experienced tropical cyclones, with cyclone Annie in 1967 the exception. This is because of its location close to the equator. The people reported however that they have experienced cyclones in the past. It was also reported that Ontong Java experiences impacts from storms, some following in the trail of cyclones elsewhere in the region (Rasmussen

et al., 2009). For instance, a storm in early 2006, coinciding with high tides, caused extensive flooding on the two permanently inhabited islands, Luaniua and Pelau.

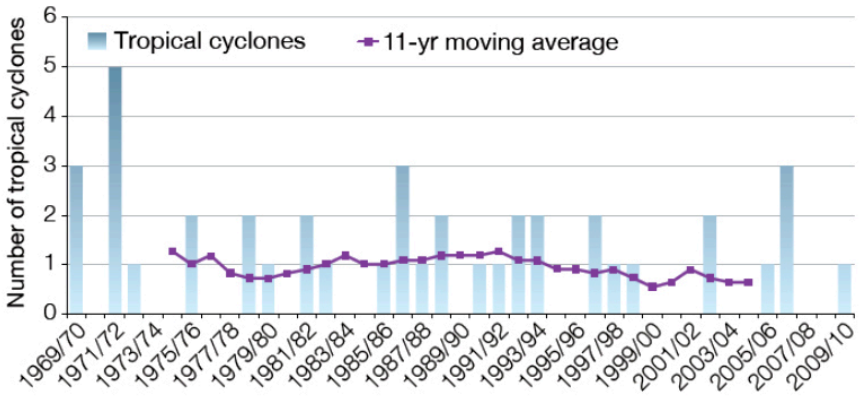


Figure 6. The number of tropical cyclones passing within 440 km of Honiara. (Source: PACCSAP Program, http://www.pacificclimatechangescience.org/)

2.2.3. Sea level

Sea level is the mean height of water in the sea between highest and lowest tides. There are long-term variations in sea level as a result of two processes: changes in the volume of water held in the ocean, which is known as eustatic sea level change; and movements in the relative height of the land surface as a result of deformations in the earth's crust, which is known as isostatic change.

Globally, sea level is increasing as air and ocean water warm and glaciers and ice sheets melt, especially around the poles. Satellite data have indicated the sea level near Solomon Islands has risen by about 8 mm per year since 1993. This is higher than the global average of 2.8–3.6 mm per year. This higher rate of rise may be partly related to natural fluctuations that take place caused by phenomena such as the El Niño-Southern Oscillation (PACCSAP, 2010).

On Ontong Java, the increasing sea level is becoming very obvious along the shorelines and exposed parts of the island. Older people who have been there for decades have also testified to this change and confirm that shoreline erosion has worsened in recent years. Many areas that people used to use as gathering sites along the coasts have now been washed away, as well as some garden sites close to the shoreline. People believe that if nothing is done, many villages and settlements will also be threatened or washed away in the near future.

SEA LEVEL RISE AND TECTONIC MOVEMENTS

Tectonic land movements, where rising and falling land are associated with tectonic activity and the extraction of water and resources such as gas and oil, also result in changes in sea level. These types of forces do not change the volume of the ocean, but the relative sea level to the land. However, these changes do affect movement of water over land, as well as estimates from satellite altimetry. This was the case in Torres Islands, Vanuatu, where a study indicated that vertical motions of the Torres Islands themselves dominate the apparent sea level rise observed on the islands, and not eustatic sea level changes as previously assumed (Ballu et al., 2011). The findings of the study highlighted that vertical ground motion must be accounted for when evaluating sea level change hazards in active tectonic regions. These data are needed to help communities and governments understand environmental changes and make the best decisions for their future.

The Solomon Islands sit on the edge of the Pacific plate, and evidence indicates that the Pacific plate lifts against the North and South Bismarck, Solomon Sea and Caroline plates (Figure 7). For instance, the volcanoes in the Solomon Islands are associated with the Solomon Sea plate as it subducts beneath the Pacific plate. In 2006, an

earthquake on Ranongga Island in the Western Solomon Islands moved 80% of its fringing reef permanently above sea level. Northern reefs became elevated 1 m above the high tide mark, whereas on the south side reefs moved 2 to 3 m above the high tide mark. It is therefore very unlikely that the increasing sea level rise now experienced on Ontong Java atolls are caused by plate tectonic movements. However, thorough seismological and plate tectonic studies should be undertaken to ascertain the impacts of plate movements and seismological activities on increasing sea level in the atolls.

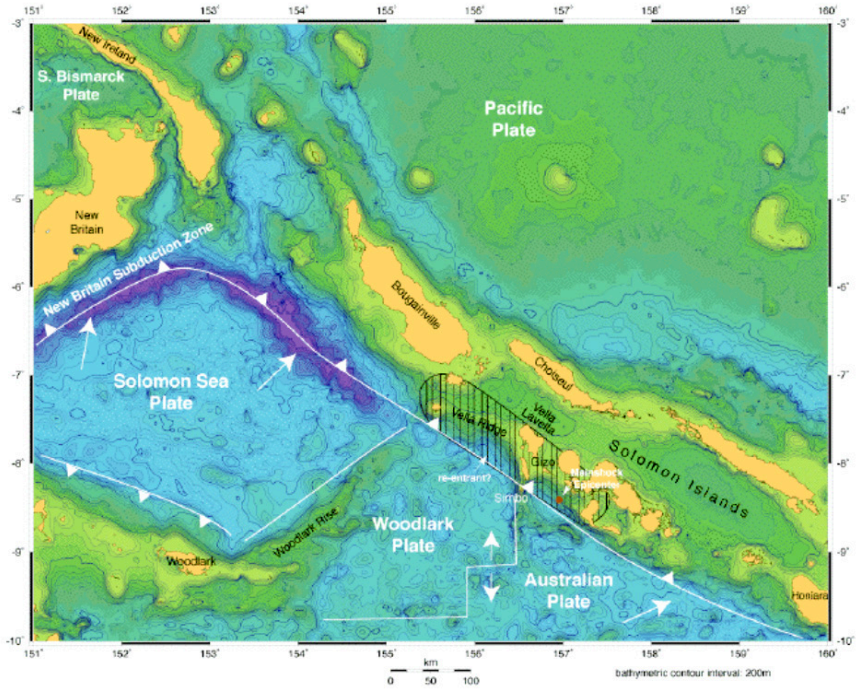


Figure 7. Plate tectonic movements, Solomon Islands. Single white arrows show the direction of the downgoing plate towards the Pacific plate. Double diverging arrows show the spreading direction across the Woodlark Ridge that separates the Woodlark and Australian plates. (Source: USGS.)

2.3. Climate and sea level projections

There is presently a lack of detailed information or knowledge regionally regarding possible future changes in climate and sea level in Solomon Islands. Importantly, there is also a lack of information on how the El Niño-Southern Oscillation (ENSO) and cyclone events might change as a result of climate change. The climate and sea level scenarios presented here are based on projections released by the Pacific Climate Change Science Program, which build on findings of the 2007 Inter-governmental Panel on Climate Change (IPCC) Fourth Assessment Report, in combination with outputs from a number of general circulation models (GCMs).

2.3.1. Temperature and rainfall projections

Recent projections for Solomon Islands indicate that annual air temperature and sea surface temperature will continue to rise. The Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program has reported that by 2030 the increase in temperature will be in the range of 0.4–1.0°C under a high emissions scenario (Table 2). Consequently there will be hotter days and warmer nights and a decline in cooler weather throughout the year. This projection is consistent with the current general experience in Solomon Islands, including in Ontong Java, where people have experienced new extremes in weather conditions, especially in terms of hotter weather.

In Table 3, projected temperature increases are given for the years 2050 and 2100 based on the IPCC best guess greenhouse gas (GHG) emissions scenario (IS92a), assuming a climate sensitivity of 2.5°C, and patterns of change

from three GCMs (BMRC, CSIRO9M2 and ECHAM3TR). Some studies have indicated only minor variations among the different GCM patterns, with a temperature increase of 0.7–1.1°C by 2050 and 1.2–2.0°C by 2100. Other studies project an annual mean trend of 0.14–0.2°C per decade. This is consistent with the temperature trend projected by the IPCC studies. As shown in Table 3, there is little variation across the longitudinal range of Solomon Islands, including the Ontong Java Atoll group.

Table 2. Projected average annual air temperature changes for the Solomon Islands for three emissions scenarios for the years 2030, 2055 and 2090. Values represent 90% of the range of the models and changes are relative to the average of the period 1980–1999. (Source: PACCSAP Program.)

	Temperature change (°C)		
	2030	2055	2090
Low emissions scenario	0.2–1.0	0.7–1.5	0.9–2.1
Medium emissions scenario	0.4–1.2	0.9–1.9	1.5–3.1
High emissions scenario	0.4–1.0	1.0–1.8	2.1–3.3

Table 3. Projected temperature increases for area latitude 5 to 10° south and the given longitudes east

GCM	Year	Longitude 155–160°	Longitude 160–165°	Longitude 165–170°	Longitude 170–175°
BMRC	2050	0.7	0.7	0.7	0.7
	2100	1.4	1.4	1.4	1.4
CSIRO9M2	2050	0.8	0.8	0.8	0.8
	2100	1.4	1.4	1.4	1.4
ECHAM3TR	2050	1.1	1.1	1.1	1.1
	2100	2.0	2.0	2.0	1.9

Inconsistency in projected rainfall levels makes it difficult to make reliable estimates, and drought projections are also inconsistent across Solomon Islands. However, according to the PACCSAP Program, the average annual and seasonal rainfall is projected to increase over the course of the 21st century. In addition, model projections show extreme rainfall days are likely to occur more often. Wet season increases are likely due to the expected intensification of the South Pacific Convergence Zone and the Western Pacific Monsoon.

2.3.2. Sea level projections

Figure 8 shows observed and projected sea levels for Solomon Islands. The observed sea levels are indicated in dark blue (relative tide gauge observations) and light blue (satellite record since 1993). Reconstructed estimates of sea level near the Solomon Islands (since 1950) are shown in purple. The projections based on emissions scenario (representing 90% of the range of models) are shown by the shaded green region from 1990 to 2100. The dashed lines are an estimate of 90% of the range of natural year-to-year variability in sea level.

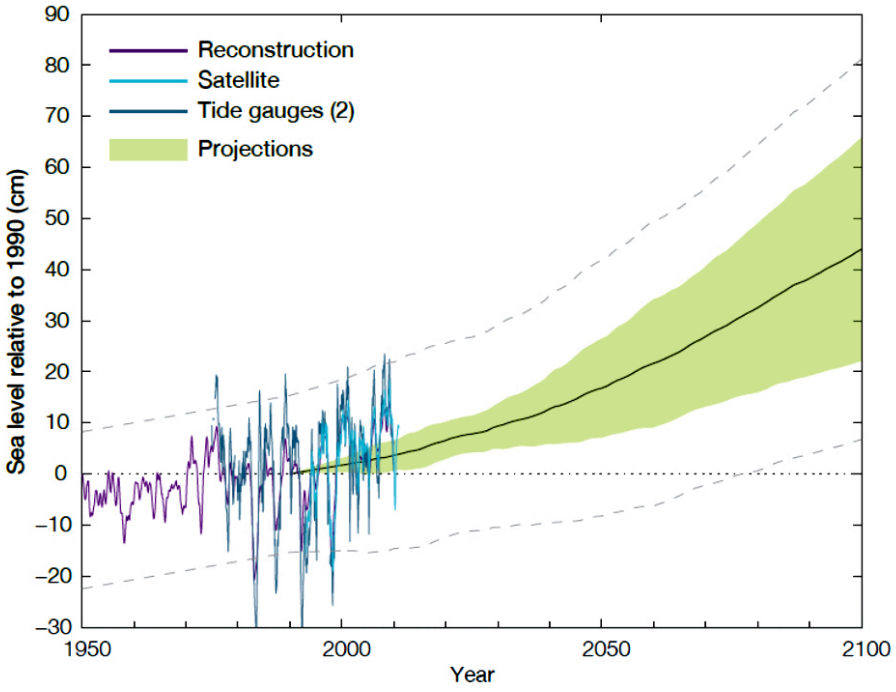


Figure 8. Observed and projected relative sea level change in Solomon Islands. (Source: PACCSAP Program, http://www.pacificclimatechangescience.org/)

2.4. Climate change impacts

The impacts of drought, tropical cyclones and storm surges, coastal inundation and erosion, sea level rise, and surface and underground saltwater intrusion are evident in food shortages and a lack of good drinking water. Exposure to impacts depends on various factors, including location and physical features. For instance, the southern coast of Pelau is not protected by reefs and therefore experiences more coastal erosion and is more vulnerable to saltwater intrusion than other areas where there are reefs.

Climate impacts are also seen in environmental and natural systems, such as loss of biodiversity. These changes can affect coping mechanisms and capacity of ecosystems. In addition, there are social implications as people adjust behaviours and practices of using natural resources.

3. THE ASSESSMENT AND ITS OBJECTIVES

The V&A assessment focused on five key areas: agriculture, food security, land degradation, forestry, and biodiversity; human settlements and health; water resources and freshwater ecosystems; energy, industry, commerce, and financial services; and coastal zone and marine ecosystems.

The main objectives of the assessment were to:

- Assess the vulnerability of food productions systems in Ontong Java Atoll in relation to climate change risks;
- Develop a baseline report on the food security situation in Ontong Java communities; and
- Identify possible adaptation options, and based on these, develop a strategy for the PACC demonstration project.

The V&A assessment was designed to be fully participatory and to provide an opportunity to discuss the key topics with the target population. The aim was to obtain information on people's thoughts on climate change issues and problems, and other related and relevant topics. The assessment also aimed to provide a 'benchmark' of the target population and their attitudes to climate change, as a baseline against which to compare changes in attitudes and perceptions over time.

4. METHODOLOGY

The V&A data collection tools consisted of:

- Household surveys;
- Community workshops; and
- Informal interviews.

The assessment team comprised members of the Eastern Development Agency (EDA) as the lead agency, and representatives from PACC PMU, the Ministry of Agriculture and Livestock (MAL), and the Ministry of Environment Climate Change Meteorology and Disaster Management (MECDM).

Prior to the assessment, EDA and PACC PMU held a workshop to train the team members on the assessment methodologies and tools.

The methodology was guided by Intergovernmental Panel on Climate Change (IPCC) technical guidelines. It examined the present conditions and generated scenarios for possible future changes in climate and sea level in Solomon Islands for the years 2025, 2050 and 2100. These scenarios are then used to examine the possible effects of climate and sea level changes on the various areas and sectors.

The assessment involved the following steps: (1) delineate the case study area; (2) inventory study area characteristics; (3) identify the relevant socioeconomic development factors; (4) assess the physical changes; (5) formulate response strategies; (6) assess the vulnerability profile; and (7) identify future needs.

4.1. Household survey

4.1.1. Scope and coverage

The survey gathered data from household units in the two communities of Luaniua and Pelau. A household is defined as a group of related or unrelated people living together in a housing unit and sharing meals. The survey involved interviewing a sample of 20% of the total households. There were 56 households from Luaniua and 20 households from Pelau (Table 4).

Table 4. Original and final samples in the household survey

Community	Original sample				Final sample	
	Estimated population	Households	Sample households	Sampling fraction (%)	Sampled households	Sampling fraction (%)
Luaniua	2057	278	56	20	42	15
Pelau	800	116	20	20	18	15

4.1.2. The questionnaire

The questionnaire (Appendix 1) was designed to solicit information on people's perceptions of vulnerability and adaptation to climate change. The open questionnaire was designed so that responses were not restrictive but to encourage respondents to provide detailed information. The questionnaire was also guided by best practices relevant to V&As, especially as recommended by IPCC.

Related information such as demographic and economic characteristics of the population and housing characteristics was also collected.

4.1.3. Carrying out the survey

Survey workers were recruited from the Ontong Java settlement in Honiara. They included competent enumerators who had been trained by one of the facilitators and had carried out previous surveys. Five enumerators were recruited, three for Luaniua and two for Pelau. All candidates were tested for competency in English and Pidgin, but most importantly they were selected because they would use their own language in the interviews. Instructions were given to enumerators and a supervisor prior to the survey. A training guide was used to ensure understanding of the procedures, terms and concepts. Field practice interviewing was not carried out due to time limitation.

4.2. Community workshops

Participatory community workshops using participatory rural appraisal (PRA) methodology were carried out in the two communities of Luaniua and Pelau (see Appendix 2).

The participatory methods can help to empower villagers to take ownership of the problem of climate change in their community, and to work together to identify the causes of the problem and to determine ways to increase their adaptation activities through community action and planning.

5. FINDINGS: CURRENT AND FUTURE VULNERABILITY

The findings on vulnerability are described below under the five key areas: agriculture, food security, land degradation, forestry, and biodiversity; human settlements and health; water resources and freshwater ecosystems; energy, industry, commerce, and financial services; and coastal zone and marine ecosystems.

Table 5 shows the perceptions of the interviewees on the occurrence or frequency of identified hazards and the impact on their livelihoods over a period of 1 year. All the people who were interviewed reported a perceived increase in the frequency of natural hazards.

Table 5. Perception of the frequency of hazards and their impact on households over a period of one year (from the household survey).

Hazard	Frequency (increasing)	Impact (increasing)
Drought	✓	✓
Flooding	✓	✓
Saltwater intrusion into food gardens	✓	✓
Saltwater intrusion into wells	✓	✓
Coastal/beach erosion	✓	✓
Storm surges and strong winds	✓	✓
Hotter days and nights	✓	✓
Unpredictable weather patterns (rainy and sunny days)	✓	✓

Table 6 shows the impact of hazards on the lives of the people of Ontong Java, as indicated during the household survey. People perceive the most vulnerable sectors to be water and food supply. Loss of cemetery land is also a major concern for the islanders, an indication of the increasing pressure on land exacerbated by an increasing population and changing climatic conditions.

Table 6. Sectors/areas being impacted by hazards (from the household survey)

Sector/area	Tick all that have been impacted	Hazards that have caused the impact	Three most impacted
Water supply	✓	Drought and over-drawing causing saltwater intrusion into wells, siltation of wells	1
Food gardens	✓	Drought, heat, saltwater intrusion, pests and diseases	2
Bush areas	✓	Increased storm surges and high tides causing coastal erosion and inundation	
Fishing grounds	✓	Sea temperature increase causing coral bleaching	
Transportation	✓	Climate variability and increasing extreme events interrupting shipping services	
Communication	✓	Climate variability and increasing extreme events damaging telecommunication lines and networks	
Loss of property	✓	Cyclone and associated flooding causing erosion and saltwater intrusion	
Loss of village cemetery	✓	Cyclone and associated flooding or inundation causing coastal erosion	3

5.1. Agriculture, food security, land degradation, forestry and biodiversity

5.1.1. Agriculture

LAND AND SOIL

Ontong Java comprises low-lying coral islands, which rise to just 3 to 4 metres above sea level. The coastal areas are highly vulnerable to sea level rise and flooding. Erosion has been an observable impact of changing tides and strong currents. Severe events such as cyclone Annie in 1967 cause significant erosion, and inevitably impact on land productivity. Land erosion is also exacerbated by factors such as poor farming practices, the cutting of palm trees and vegetation, and population pressure. It is also recognised that erosion is a natural characteristic of low-lying atoll islands.

The soils of the two land systems in Ontong Java, *Lomousa* and *Pusaraghi*, are not highly productive, especially with increasing loss of topsoil humus. The low-lying nature of the agricultural land, which is just 15 metres from the shoreline, is also vulnerable to soil contamination from saltwater intrusion. This is currently causing harm to the swamp taro crop, an important staple of the islanders' livelihoods.

FOOD CROPS

The land is mainly covered by coconuts. The villages at Pelau and Luaniua grow backyard crops like banana, stem taro, kongkong taro, cutnuts, slippery cabbage and pumpkin. Pigs can be seen tethered under the coconuts near the villages.

The main crop, providing most of the families' daily food, is swamp taro (*kakake*). A family of six or seven members farms an average of 150 square metres. The swamp taro grown on this area can last the family for 6 months., but some of the larger families use up their swamp taro in a shorter time, especially at times when they are not able to get alternative food like rice and flour.

The range of food crops is very limited because of the poor soils and lack of knowledge about or access to suitable crops. With only one staple food crop – swamp taro – the communities are highly vulnerable to food shortages and hunger.

When there are food shortages, people have to rely on buying rice and other imported foods. Collecting bêche-de-mer is the main commercial activity from which people derive income, with copra a secondary source of income. People reported that when the bêche-der-mer trawling is closed they cannot buy food supplements like rice and flour.

SALTWATER INTRUSION AND DAMAGE TO SWAMP TARO

According to the islanders' observations, saltwater intrusion has recently increased due to sea level rise and occasional sea surges during bad weather, contaminating the swamp taro growing areas. The people reported that swamp taro contamination now occurs at locations where it had never been experienced in the past.

In 2008, after high swells, a Ministerial report stated that: [sic] "The waves of the high swells have caused much damage to the agriculture of the atoll people. Severe in Luaniua, moderate in Pelau. High waves drives through the coast and into the planting fields that are located very close to the coast. The inner kakake fields were affected by salt water intrusion. Due to the high waters that came with the waves, salt water intrude in to the water table as a result that the kakake fields were flooded with saltwater. As a result of those kakake plants went brackish, wilt then die after. Kakake fields or gardens were flooded from waves and upwelling" (Kauhiona and Fugui, 2008).

Damage to swamp taro is also evident in the rotting of immature taro tubers. While taro rotting can be attributed to factors such as soft rot, a disease that can be caused by several species of *Pythium,* and sclerotium rot, which is caused by *Sclerotium rolfsi,* long periods of saltwater flooding and intrusion have exacerbated the damage caused

by the diseases. As reported by the Ministry of Environment (Kauhiona and Fugui, 2008), even inland garden areas have been flooded by seawater causing swamp taro tubers to turn yellow and bitter rendering them unsuitable for consumption.

PESTS AND DISEASES

A variety of pests and diseases exist on Ontong Java and are causing serious damage to taro. Taro beetles (*Papuana* spp., e.g. *Papuana huebneri* and *Papuana woodlarkiana*) are a major cause of damage to taro on the atolls. Adult beetles feed on underground corms, creating tunnels while feeding. Damage may be such that the corms cannot be used for consumption. Above ground, symptoms vary with the age of the plants: young plants may be killed as the beetles invade the shoot, while other plants grow more slowly and a few or all of the leaves will wilt.

Severe losses have also been suffered in the past as a result of planthoppers. Heavy infestations of taro planthopper cause plants to wilt and, in exceptional cases, to die. Sap sucking and the laying of eggs cause sap exudation, which forms small red encrustations on the petioles, particularly at the base. Older leaves are affected by severe infestations during dry weather: the petioles bend down giving the plants a splayed appearance, and the leaves die prematurely. Taro planthoppers transmit *Colocasia* bobone disease (?rhabdovirus), and possibly a related virus, taro vein chlorosis rhabdovirus. These viruses are associated with the alomae and bobone virus diseases.

The spiralling whitefly (*Aleurodicus disperses)* is another pest causing damage to taro on Ontong Java. The pest pierces through taro leafs and sucks the sap. This leads to premature death of plants when infestations are high. Indirect damage can be caused by accumulation of the honeydew and the waxy, white, fluffy or woolly material produced by the insect. Honeydew serves as the substrate for sooty moulds, which blacken the leaf, retarding photosynthesis and reducing plant health.

Rats (*Rattus rattus, Rattus norvegicus*), or *keiore* as they are called locally, feed on taro corms and leaves, while birds such as parrots attack taro and also feed on pawpaws (*Carica papaya*) and bananas (*Musa* spp.). The degree of damage they impose is however, manageable.

Taro blight (caused by *Phytophthora colocasiae*) is a major disease causing damage to taro on the atolls and wetlands. It causes purple to brown circular water-soaked lesions and has resulted in considerable losses to the crop on Ontong Java atolls in the past. In the Pacific taro blight is one of the most devastating taro diseases. In Solomon Islands, the disease has resulted in taro being partially replaced by sweet potato (Rasmussen et al., 2009).

Taro rot is also a major disease that is threatening crops, especially taro, on the atolls. With a lack of scientific knowledge on taro diseases, the islanders have attributed many of these rots to increased flooding and saltwater intrusion over the years. However, it is known that several species of *Pythium* cause taro soft rot, with wilting and chlorosis of leaves. Sclerotium rot caused by *Sclerotium rolfsii* is characterized by stunting of the plant, rotting of the corm and formation of many spherical sclerotia in the corm. In both flooded and upland taro, dark brown spots that appear in older leaves are caused by *Cladosporium colocasicola* and *Phyllosticta colocasiae*.

Yellowing of the taro foliage is often seen, which indicates a lack of nitrogen. However, discolouring of taro leaves can also be caused by *Hercothrips indicus* (synonym: *Heliothrips indicus*) which can result in a silvery discoloration of the leaves and severe leaf shedding.

Some crops have been adversely affected by severe heat from the sun and the sand. Conditions could be improved if the ground was covered with cover crops such as legume plants. Several species have been tried, for example Puero, Centro, and Siratro were tried; only Siratro survived but was not promising. The importance of raised beds underlain by commercial plastic is increasing.

The household survey indicated no evidence that food crops, other than taro, are under threat from disease. It was discovered that one reason why all taro is imported from Temotu Province is because it is the only province that is free from the destructive viral taro diseases alomae and bobone. However, the lack of knowledge of diseases and capacity to undertake thorough pathological examinations and assessments may result in a lack of awareness of the existence of diseases.

THREAT FROM INTRODUCED SPECIES

There is concern that any introduced species, whether introduced deliberately or accidentally by humans or by natural events such as cyclone winds or flood water, could harm native species and the ecosystem. Hence, it is important that when introducing new species, including new planting materials to the island through the current food security projects, thorough assessments be undertaken to ensure these plants will not become invasive.

The people described an incident from the past when the traditional taro variety was wiped out. The people of Luaniua attributed the loss to saltwater flow into taro gardens after cyclone Annie hit them in 1967. Pelau people on the other hand, explained that a newly introduced taro species called *dodo creek*, which was introduced by the Luaniua people in an attempt to revive taro on the island, brought an exotic disease. They also believed that when the *dodo creek* was planted it out-competed the native species. No thorough studies were undertaken to ascertain the specific cause of the loss, although assessments carried out by the Disaster Management Office after cyclone Annie concluded that it may have been caused by an existing viral or fungal disease, which was able to exploit the weakened ecosystem following damage by cyclone Annie. The introduced species was removed but the lost native species were not reintroduced.

About a decade ago in 2000, a new problem arose with the swamp taro. It was noticed that tubers were rotting at their bases. Initially the issue occurred mostly in gardens that were located in the areas close to the coast on both islands, but later it also slowly affected the patches in the centre and the southern end of the island. Information gathered from the people on the atoll showed that many of them believed that the rotting of plants is due to increasing sea level rise and saltwater intrusion over the years. However, the symptoms could also be due to water-borne fungal diseases.

5.1.2. Food security

The household survey and community workshops revealed that the food security status of Ontong Java is not stable. The following areas were highlighted.

SOURCES OF FOOD

All of the respondents said that they have a food garden. About 80% of them said that they only have coconut and swamp taro in their gardens, partly because there is lack of suitable land to grow other crops. Only 20% of the respondents said they have grown other crops such as banana, true taro, pawpaw and pumpkin.

The survey revealed that 85% of people take cassava on a monthly basis. The cassava comes by boat from Honiara, as none is grown on the islands. Ninety-three percent also take rice, flour, biscuits and other food items on a weekly basis, also depending on the schedule of ships to the islands.

Saltwater intrusion into the swamp creeks has affected the growth and yield of the swamp taro. This exacerbates the food security situation because Ontong Java lacks an alternative staple food crop.

The loss of swamp garden land combined with increasing population has exacerbated land scarcity on the islands. One lady interviewed said that it is very hard to find a new piece of land because the land was divided by their great grandfathers in the past and once it is lost there is nowhere else to get new land. She added that even those whose land is not badly affected are finding it hard to manage because resources are limited and there are too many people with needs. The situation is exacerbated by the very high prices of goods in the shops.

INCOME

Table 7 (next page) shows the sources of annual income of a sample of 60 people interviewed during the household survey. Marine resources and specifically bêche-de-mer provide the main source of income. The current government ban on the harvesting of bêche-de-mer has posed a real challenge to the people's livelihoods; however, this is needed to protect the marine resource from being harvested to extinction. There have been reports in the media that the ban has not stopped some people from harvesting bêche-de-mer and selling it across the border in Papua New Guinea.

This situation implies a need for the people on the island, their leaders and the provincial and national authorities to closely collaborate and establish long-term mechanisms whereby the endangered marine resources can be sustainably conserved for the benefit of current and future generations. The establishment of Marine Protected Areas (MPAs) could be a way to help do this. Furthermore, awareness and education to understand why the ban was put in place, the benefits of letting the resource regenerate, and the concept of over-harvesting need to be conducted for the people.

Ontong Java fishermen collect only two species of bêche-de-mer for processing – the teat fish (*Microthele nobilis*) and the black fish (*Actinopyga miliaris*). The *M. nobilis* and *A. miliaris* populations of the Ongtong Java lagoon have suffered considerable exploitation within the last decade and there is no doubt that their overall numbers have decreased, especially in the shallower parts of the lagoon. Now fishermen must travel considerable distances and fish in deeper water to find substantial catches of these animals. To make a useful assessment of the future of the bêche-de-mer industry, information on the reproduction, growth, recruitment and life cycle of commercially important holothuroids will be necessary.

Table 7. Sources of annual household income (from the household survey).

Source of income	Value (SBD)	Percent (%) of total income	Percent (%) of total population sample
Bêche-de-mer	12,160,000	95.4	100.0
Trochus	480,000	3.7	100.0
Shark fin	60,000	0.47	100.0
Copra	13,333	0.1	7.0
Pig	16,000	0.13	3.3
Wages and salary	12,000	0.09	1.3
Remittances	1000	0.008	1.3
Total	12,742,333	100.0	100.0

HOUSEHOLD EXPENDITURE

Table 8 shows the annual expenditure distribution of 60 people on Luaniua. Food makes up more than half (63%) of the people's total expenditure. This also accounts for more than half of the income earned by the people annually (see Table 7 on annual income distribution above). Apart from food which is mostly imported goods, the people of the atoll are also heavily reliant on equipment and materials necessary for their survival that can only be bought from Honiara.

Although the people of Ontong Java earn a good income they need to manage it in a sustainable way. It is strongly suggested that financial management training is conducted for the people of Ontong Java.

Table 8. Annual household expenditure in Solomon dollars (SBD).

	Amount (SBD)	Percentage of total expenditure
School fees	68,000	0.7
Transport costs (e.g. fuel for outboard, payment for ride to town)	922,400	8.9
Food	6,518,160	63.0
Personal expenses (cigarette, alcohol, clothes, betel nut, etc.)	706,310	6.8
Household equipment (pots, pans, buckets, radios, lamps, radios, etc.)	480,000	4.7
Disposable household products (soap, washing powder, etc.)	390,000	3.8
Other equipment and assets (nets, boat parts, tools, engine parts etc.)	1,248,000	12.1
Donations to church ceremonies, weddings etc.	15,000	0.4
Total	1,034,870	100.0

TRANSPORT AND TELECOMMUNICATIONS

Being so remote, transportation, especially shipping, plays a vital role in the livelihoods of Ontong Java people. Ontong Java does not produce enough crops to feed its population and so they rely on ships to bring in food from Honiara. The survey revealed that people of Ontong Java eat a lot of cassava, sweet potatoes, rice, flour, biscuit and other imported food items. A reliable shipping or transportation service is therefore essential to ensure food security of the islanders. This includes the establishment of alternative trade routes to boost trade and interisland relationships.

Telecommunication also plays a vital role in the vulnerability of the islanders, as it allows them to access information about weather patterns and forecasts, and to plan ahead to enhance their food security, for example when extreme weather events threaten. Simple technologies such as rain gauges and access to mobile service networks can help a lot in disaster mitigation and preparedness. Hence, reliable telecommunication services are essential for the enhanced security and adaptation of the people of Ontong Java.

5.1.3. Land degradation

The survey revealed that soil fertility is a major issue in Ontong Java. This is because the land has been extensively used for agriculture without replenishing nutrients. An elder on Luaniua recalled that the gardens are on the same areas since their forefathers inhabited the islands many years ago, adding that soil in the past was very dark and the water in the swamp was good to drink. Today the soil has lost its colour, water is brackish in most areas and the soil is mostly sandy. The elder thought that the loss of soil fertility was due to loss of traditional knowledge by the younger generations. This reflects a long history of poor land use practice, which is related to unsustainable use of available land and in some instances use of inorganic fertilisers to boost agricultural production.

Other causes of land degradation include the impacts of natural occurrences such as high waves, storm surges and strong winds from passing tropical cyclones. Even though tropical cyclones do not occur often on the atolls, cyclones passing south of Solomon Islands can cause coastal flooding and beach erosion. From observation it is clear that coastal erosion has been affecting the atoll for quite a long time and is continuing. For instance, the islanders identified that an area that was once their cemetery has been eroded away. However, proper time series shoreline analysis needs to be undertaken to determine the trend of coastal erosion on the atolls.

5.1.4. Forestry

There is no longer forest cover on the atolls. Vegetation consists mainly of coconuts with sporadic patches of pandanus and shrub undergrowth mixed with ferns. Along the shoreline are isolated pine trees with beach shrubs below. The lack of forest cover makes communities more vulnerable to heat from the sun and to strong winds.

5.1.5. Biodiversity

Biodiversity refers to all living organisms in land, freshwater and marine ecosystems. In Ontong Java, the vulnerability of biodiversity to climate change has been evident for some time (Hansell, 1967; Yee et al., 1999; Kauhiona and Fugui 2008; Rasmussen 2009). Many species have become extinct. On Ontong Java, tree density and species richness is decreasing. Healthy biodiversity is linked to resilience, for example it increases livelihood options, and the vulnerability of the people of Ontong Java is therefore affected by reduced biodiversity.

5.2. Human settlements and health

Findings from the assessment showed that there were many ways in which climate change could affect human settlements and health in Ontong Java. Some of the impacts are direct, others are indirect.

5.2.1. Human settlements

Communities have been disrupted particularly along the coast due to sea level rise and coastal inundation and erosion. Some settlements have already relocated inland from their original sites in response to sea incursion over some decades. In Pelau Island quite a significant coastal area has been eroded away, forcing villagers to move inland.

The total population of Ontong Java is 2,857 people (2009 Census report). However, population displacement and migration, particularly to Honiara, is likely to occur as impacts of climate change increase.

The survey revealed that all of the respondents favour the opportunity to be relocated to bigger islands. The motives for relocation were mainly fear and uncertainty, and people were mostly not aware of other adaptation options. Relocation is therefore an important need for the people of the islands, but it is noted that it is a very difficult process that involves social disruption, as well as significant costs such as new infrastructure.

5.2.2. Health

A number of indirect impacts of climate change on human health were identified. A shift could occur in the location of some vector-borne diseases, such as malaria, in response to changes in rainfall and temperature. Mosquitoes thrive in locations with waterlogging and poor drainage, especially in the swamp taro creeks and dense coconut groves. At certain times of year when mosquito breeding is favoured by temperature and rainfall, people often move to other small islands to avoid the mosquitoes.

Direct impacts include health problems caused by saltwater intrusion affecting the wells. During drought periods people resort to wells for their drinking water, and where water is contaminated there may be an increase in illnesses such as diarrhoea.

Figure 9 shows intake of different food types over various time periods for 60 people interviewed during the household survey. While all of the people interviewed thought they have daily intakes of energy and protein every day, there is much less intake of protective foods. While the people's intake of protective food may be high within a single month, the intake of protective food varies over a period of 6 months. This may be related to the seasonal aspects of weather and climate on the atolls which may affect the availability of protective foods on the islands.

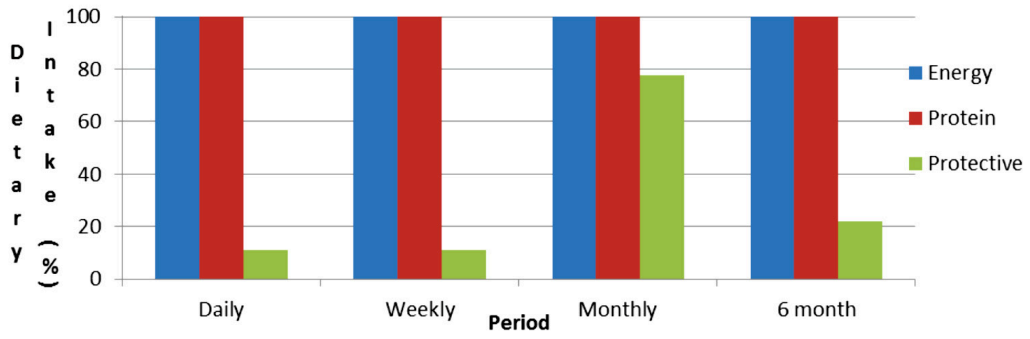


Figure 9. Intake of different food types in Ontong Java (from the household survey).

5.3. Water resources and freshwater ecosystems

Changes in weather and climate profoundly influence water resources, and can increase vulnerability. Generally, the people of Ontong Java rely on wells and water tanks as well as creeks for their water supply, for both domestic (drinking, washing and cleaning) and agricultural needs (watering of crops). Rainwater collected in water tanks is the main source for drinking and for cooking. Well water, which draws on the freshwater lens, has been contaminated with saltwater making it brackish and unfit for drinking. However, when there are dry spells well water is used for washing.

According to the household survey the Pelau community has access to sufficient water; however the Luaniua community is not so fortunate. The population of Luaniua is 2,057, and that of Pelau is 605. There are 13 wells and 68 water tanks on Luaniua, and 17 wells and 55 water tanks on Pelau. The average size of the tanks is 800 gallons (Fugui, 2008).

The water need for the Luaniua community is 69,938 gallons. Currently the 68 water tanks provide 54,400 gallons, a shortfall of 15,538 gallons. This is equivalent to 20 tanks of 800 gallons each. It can be seen from this calculation that Luaniua needs another 20 storage tanks.

The high dependence on wells may result in depletion of the freshwater lens under the island. Studies are needed to determine the impact of wells on the atoll's underground freshwater lenses.

Drought has negative effects on food gardening, and can also enhance the growth of invasive grass and weeds, which suppress native species. Erratic rainfall can also affect sanitary and health conditions in the two communities, for example it may affect waste disposal. Human waste is disposed of at sea.

5.4. Energy, industry, commerce and financial services

5.4.1. Energy

The survey showed that 100% of respondents use solar power for lighting, 83% use firewood for cooking and 17% use Speed-E-Gas for cooking. The forest vegetation of Luaniua and Pelau is now very limited mainly due to overharvesting; much has been cut down to dry the lucrative marine product bêche-der-mer and for cooking.

5.4.2. Industry

There is no industry of any sort other than small primary industries. There is harvesting of bêche-der-mer, trochus, shark fin, and shellfish, and some copra production.

5.4.3. Commerce

The atolls have some trading businesses, especially in consumer goods and retailing. Commerce is however very much influenced by clientalism, where groups are formed by business people, especially around family ties as the means of trade relations. Often people sell produce to business owners who offer goods in exchange. A major problem in this system is that businesses often over-charge, distorting the value of goods and exploiting ordinary people, especially women and children.

5.4.4. Financial services

There are no financial services such as banking or any credit services. People keep their own money and when goods and services are available they use their savings to pay for the goods. The commerce and trade system described above also serves as the financial system on the islands.

5.5. Coastal zone and marine ecosystems

The household survey showed that the community believed that the sea level has been rising over the past 40 years and it has affected the coastal areas of the atoll islands of Ontong Java. In particular, people had witnessed increasing beach erosion and coastal flooding.

The marine ecosystem is central to the livelihoods of the islanders. Hence, despite the government ban, the two communities continue harvesting marine resources including bêche-der-mer, shark fins, trochus, and other seashells. With an increasing population, the pressure on these resources will likely increase over time. It is vital that appropriate actions are undertaken by the government and other stakeholders, including the PACC project, to ensure long-term measures are put in place to control harvesting of highly vulnerable resources, but also to ensure that the island's people are able to survive.

6 FINDINGS: CURRENT AND FUTURE ADAPTATION STRATEGIES

Table 9 shows the issues and problems, and some possible coping strategies and solutions, identified by the communities at the participatory workshops.

Table 9. Issues, problems, coping options and possible solutions identified at the community workshops

ISSUES	PROBLEMS	COPING	POSSIBLE SOLUTION
Agriculture, food security, land degradation, forestry biodiversity	• Loss of soil • Lack of crops, trees due to indiscriminate cutting for firewood and demand from growing population • Introduction and existence of invasive species, pests and diseases	• Need more mulching • Need to plant more mangroves and fruit trees • Boost biosecurity mechanisms	• Need more good soils, need to build seawall • Restrictions through closer collaboration with relevant authorities • Educate locals of the importance of trees and ecosystem on climate change adaptation
Human settlements and health	• Overcrowding • Sickness • Hunger • Land shortage • Domestic violence	• Migration • Keep clean, hygiene • Balanced diet, hard work • Forward planning • Married out • Awareness programme and teaching	• Control underage marriages • Need more medicine, nurse, clinic • NDMO supplies • Resettlement • Police post
Water resources, wetlands, freshwater ecosystem	• Saltwater intrusion (sea-level rise) • Lack of freshwater, freshwater more brackish	• Shifting cultivation • Dig more wells • Plant more coconut trees, plant on higher ground	• Move to better gardening locations (good soils) • More water tanks • More mulching
Energy industry, commerce and financial services	• Too expensive • Destroys ocean environments and resources • Lack of alternatives	• Use fire and shell coconut for lighting, use outrigger canoes for sailing	• Use solar power, pressure lamps, manpower
Coastal zone and marine ecosystem	• Coastal erosion • Unsustainable and overharvesting of marine resources	• Plant more trees along coast • Build-up coastal debris to create higher coastline • Build seawall • Plant mangrove • Education and awareness on impacts of unsustainable practices and overharvesting of marine resources • Government imposed bans and imposition of marine protected areas around the lagoon	• Request outside expertise • Engage community leaders, women and youths in consultations, mobilisation and awareness • Establish close collaboration with relevant authorities both at national and provincial levels

The adaptation options that were identified from the household survey and the community workshops are discussed below. The discussion also includes expert input from the PACC project team.

6.1. Agriculture, food security, land degradation, forestry, and biodiversity

6.1.1. Agriculture

Agriculture and food production could be improved by investing in better agricultural management and technology. Because of the poor soils of the atoll islands it is essential that appropriate farming systems are designed and suitable crop species identified, and appropriate training and awareness carried out. This should include educating people on the adverse long-term effects of the use of inorganic fertilisers. Instead, people should be encouraged to use local resources such as dried seaweeds as organic mulch or fertilisers to boost humus composition and soil fertility.

It is also important to encourage sustainable and environmentally friendly traditional practices of maintaining and restoring soil quality, for example the use of household waste such as taro and banana cuttings and peelings as mulch. However, damaging traditional practices such as 'slash and burn' should be discouraged.

There are some existing projects aimed at addressing the constraints posed by climate change to agriculture productivity, for example the Anglican Church of Melanesia (ACOM)'s Food and Water Security Project. This project is being implemented in Ontong Java, however many of the activities have not been carried out because of insufficient funds.

SOIL IMPROVEMENT USING LEGUMES

The use of cover crops is essential in sandy soil conditions, to protect the soil from adverse heat and also from torrential rain. The cover crops also help to smother weeds and preserve useful soil organisms. Leguminous cover crops such as vine legumes also help to increase soil nitrogen as these plants fix nitrogen.

The ACOM food security project has trialled the tree legume *Leucaena* with some positive results (ACOM Project Report, 2011). However, *Luecaena* is also an invasive species and is causing damage in many Pacific Island countries where it has been introduced to improve soil fertility, such as in the Micronesian atolls and Fiji. Hence, while *Leucaena* may be recommended for improving soil fertility, its introduction must be carefully considered as it may pose a direct threat to the already fragile biodiversity of the atolls.

ATOLL PERMACULTURE

Mixed farming (agroforestry) is recommended for Ontong Java atolls. Because land is scarce it is beneficial to incorporate many crop species in one garden area. However, careful planning is needed in order to plant the right tree crops, root crops and vegetable crops.

The ACOM Climate Change Food Security Project in Ontong Java has developed an agroforestry system which they call 'atoll permaculture'. They have identified trees, root crops and vegetable crops (Table 10), as well as salt-tolerant crops (Table 11), that can be included in the system. This system is designed to sustain the soil, the diverse plant community, wildlife, and the system itself. It becomes self-sustaining, self-regenerating and self-mulching (Bonie, 1993). Other vegetables crops may also be incorporated in the system, but they may need special treatment such as raised beds and or trellises.

Mulching prevents weed growth, keeps the soil temperature constant, adds organic matter and nutrients to the soil, and helps conserve soil moisture. The atoll permaculture system provides good mulch from tree litter.

It is expected that the atoll permaculture system will not displace the traditional swamp taro farming, but will be compatible. The system will likely be established in different areas to those where swamp taro is grown.

Table 10. Crops suitable to include in atoll permaculture systems on Ontong Java, identified by the ACOM Climate Change Food Security Project.

Tree crops	Root crops	Vegetable crops
• Breadfruit (*Artocarpus altilis*) • Polynesian chestnut (*Inocarpus fagifer*) • Funny face (*Spondias dulcis*) • Malayan apple (*Syzygium malaccense*) • Local avocado (*Burkela obovata*) • Cutnut (*Barringtonia procera*) • Alite nut (*Terminalia catappa*)	• Swamp taro (*Cyrtosperma chamissonis*) • Kongkong taro (*Xanthosoma sagittifolium*) • Stem taro (*Alocasia esculenta*) • Selfish taro (*Colocasia esculenta*) • Topia • Pacific yam (*Dioscorea nummularia*)	• Bananas -3 varieties (*Musa* sp.) • Pawpaw (*Carica papaya*) • Pumpkin (*Cucurbita pepo*) • Eggplant (*Solanum melongena*)

Table 11. Salt-tolerant crops suitable for including in atoll permaculture systems on Ontong Java, identified by the ACOM Climate Change Food Security Project (Bonie, 2010).

Trees	Root crops	Vegetable crops	Tree legumes	Legumes/grasses
• Alite (*Terminalia catappa*) • Chestnut • Avocado (*Persea americana*) • Apple (*Malus domestica*) • Breadfruit (*Artocrapus altilis*) • Banana (*Musa* spp.) • Cutnut (*Barringtonnia procera*) • Coconut (*Cocos nucifera*)	• Swamp taro (*Cyrtosperma chamissionis*) • True taro (*Colocasia esculenta*) • Kongkong (*Xanthosoma sagittifolium*) • Topia • Pacific yam (*Dioscorea nummularia*) • Shade pana • Cassava (*Manihot esculenta*) • Kumara (*Ipomoea batatas*)	• Pumpkin (*Cucurbita maxima*) • Cucumber (*Cucumis sativus*) • Melon (*Citrullus lanatus*) • Pawpaw (*Carica papaya*) • Aibica • Beans	• *Gliricidia* • Rain Tree	• Centro • Siratro • Puero • Koronivia

PEST AND DISEASE PREVENTION AND CONTROL

There is concern over the whitefly (*Aleurodicus disperses*) in Pelau island. The insect pest attacks taros, pawpaw leaves and some local trees. Control options include the use of dilute solutions of soap. Biological control may also be feasible. The parasitic wasp, *Encarsia ?haitiensis*, has proved to be a very efficient means of controlling spiralling whitefly wherever it has been introduced. In some cases, it appears that the parasitoid has been introduced unwittingly, together with its host. In these cases, a balance has been established and further intervention is not required.

There is fear that the introduction of new crops to the atoll islands may bring in new pests and diseases. Introduced crops could also become invasive species, for example as has been seen with *Leucaena*. Therefore quarantine is important and the relevant authorities must be vigilant. Preventive measures must be taken to ensure invasives and other pests harmful to the already vulnerable ecosystem and biodiversity of the atolls do not make their way to the islands.

Biosecurity is a strategic and integrated approach that encompasses policy and regulatory frameworks (including instruments and activities) that analyse and manage risks in the sectors of food safety, animal life and health, and plant life and health, including associated environmental risk. In Solomon Islands a cross-sectoral or multi-sectoral approach is required to boost biosecurity. The issue is not only important for agriculture and regulators but the economy as a whole.

Solomon Islands is an affiliate of the Food and Agriculture Organisation (FAO) and FAO has sound standard procedures, systems and practices in place to promote biosecurity. The Government must work closely with relevant provincial authorities and the two communities on the islands to minimise or control the intentional or accidental introduction of invasive species to the islands.

Making people aware of the importance of biodiversity is an important step in promoting biosecurity. Involving communities in initiatives to boost biosecurity is a very effective way of engaging people and ensuring programmes and projects are successfully implemented.

INFORMATION AND CAPACITY BUILDING

Information is critical, to build knowledge and capacity to adapt. Information about climate change and its impacts on agriculture need to be disseminated. There is also a need for information about soil-tolerant crops and other agricultural products and technologies that could support the islands' adaptation efforts.

Capacity building of farmers is also important. Although Ontong Java people are well known for their achievements in growing swamp taro, they will need training in new methods and skills needed for new farming systems.

6.1.2. Food security

Increased self-reliance, planting appropriate tree species, using agroforestry and organic farming, and maintaining adequate food supplies will lessen food insecurity. Soil improvement and water harvesting should be given high priority. Government initiatives such as improving transportation and offering transport subsidies will also be important so that food can be brought from Honiara. Food such as cassava, kumara and a range of consumer goods are currently purchased in Honiara and shipped to Ontong Java.

FOOD PRODUCTION

Agriculture improvement

Improving agriculture on Ontong Java should include introducing and promoting mixed multiple cropping and agroforestry (atoll permaculture); the identification and use of salt-tolerant crops and disease-resistant, quick-maturing crops (cassava sticks, fruits and nuts); the use of raised beds as a safeguard against saline soils; proper preservation of seeds to safeguard succeeding farming seasons; the use of organic manure instead of chemical fertilisers; and pest and disease control and quarantine.

The ACOM Food Security project is providing some useful information and lessons, and an option for the PACC project would be to join forces with ACOM and build on this work. This process would require execution of a Memorandum of Understanding between the PACC project, the Ministry of Agriculture and Livestock and the ACOM.

Satellite farm commune

Currently much food, including rice, cassava, kumara and vegetables, is imported from Honiara. However, these crops could be grown by the people of Ontong Java in another location and shipped to Ontong Java after harvest. It is strongly suggested that the Government assists in purchasing or leasing a piece of good agricultural land which the people of Ontong Java can farm. This would also facilitate the resettlement of part of the atoll population. The ideal area would be on the Guadalcanal plains.

Traditional food preservation methods

Another recommendation is to encourage food processing and preservation by traditional methods, for example, the drying of fish and shellfish which are common delicacies in times of food shortages. Improved facilities and the introduction of new simple technologies such as solar power for drying are also needed.

INCOME

People rely on marine resources, and specifically bêche-de-mer, for the majority of their income. However, due to unsustainable harvesting, the government has imposed a ban on collecting these animals. It is suggested that the people of Ontong Java be provided food subsidies for the period that the ban is in place. The government should also provide alternative sources of income such as creating niche markets in Honiara for dried fish, and should consider providing facilities to enhance sustainable economic production, such as provision of cool storage rooms, clam farming and so forth.

SHIPPING

Being so remote from the rest of the country, shipping plays a vital role in food security. It is suggested that the Government initiative on transport subsidies be strengthened.

6.1.3. Land degradation

Land degradation has been exacerbated by coastal flooding and erosion due to storm surges and king tides. Sea level rise has also played a role in saltwater intrusion which has caused wells to be contaminated as well as swamp taro creeks and garden areas.

The following are recommended actions for managing land degradation: the avoidance of monocropping in preference for mixed cropping; the construction of raised beds to help protect salt-susceptible crops; the establishment of community woodlots with fast-growing plant species that yield domestic fuel; and better land-use and management practices.

6.1.4. Forestry

It is recommended that reforestation is encouraged to provide coastal protection and fuel wood. Forest trees suitable for coastal regions should be identified and promoted, for example trees such as *hekau* and *Barringtonia asiatica*. Planting of fruit trees should also be considered, to provide alternative food sources during times of natural disasters and hunger.

Other species such as *Leucaena leucocephala*, which has been introduced by the ACOM Food Security Project, could be important for fuel wood and its litter for mulching. However, given its highly invasive character, it is important that it is introduced within a controlled environment.

6.1.5. Biodiversity

Encouragement of small woodlots of specially selected species that are not invasive will in turn promote biodiversity. Other options to boost or enhance the fragile biodiversity on the islands should also be explored. This includes replanting of mangroves along the coastlines which provide habitats for marine species as well as protecting the shoreline from erosion.

6.2. Human settlements and health

The household survey revealed several strategies that can mitigate the negative effects of climate change on human settlements and health.

6.2.1. Planning for relocation

The survey showed that 100% of respondents favour the opportunity to be relocated. However, alternative options may not yet have been fully explored by the communities.

It was stated in the country's initial National Communication that "Resettling options may become necessary for some areas but because of their high social, environmental and economical cost would only be considered as last resort options" (Ariki, 1997). However, more recent inundation and flooding, for example in Ontong Java in

2006, may have changed opinion on this. The people themselves are in favour of relocation to bigger islands if government assistance is available. Considering the time and resources needed for community relocation, it is recommended that initial investigations begin as soon as possible, such as initial consultations with concerned local communities, provincial governments, dioceses, national government, NGOs, possible land donor communities, and other stakeholders.

6.2.2. Health

The survey revealed that health facilities in Ontong Java are insufficient. It is suggested that the health centre is improved by providing a building, stocking with appropriate medication and adequate staffing. Other options relating to climate change adaptation include preventative measures against mosquitoes, developing efficient and safe water systems, and data gathering and archiving of diseases associated with climate change and their seasonal variations.

6.3. Water resources and freshwater ecosystems

A number of strategies were identified under this sector. For individuals, households, and communities, the following were suggested:

- Provide adequate water tanks for the needs of the two communities;
- Use of better water storage equipment such as non-rust water tanks;
- Improved rain catchment strategies; and
- Develop community water resources for humans, animals and crops.

It is recommended initially that 40 water tanks be supplied to the two communities to meet their current water needs. Supply should be proportional to the populations of the two communities, which are 2,057 (276 households) in Luaniua and 605 (116 households) in Pelau. This would mean 30 water tanks for Luaniua and 10 for Pelau.

6.4. Energy, industry, commerce, and financial services

It is suggested that the use of solar energy continues, especially to provide lighting and other electrical needs. New woodlots should be established to provide firewood for cooking.

It is suggested that a cooperative form of business development be considered, which will enhance availability of financial services and address financial literacy for communities. In addition, other financial services and activities such as credit unions, with the assistance and support of Solomon Islands Credit Union, and a women's fund, should be considered and encouraged.

6.5. Coastal zone and marine ecosystems

It is important that the shoreline is stabilised through planting of trees along the coastline. Mangroves grow well in the swamps of the islands but not along the coastline, and research is needed to determine the reason for this and how to enable mangrove proliferation on the coasts. Construction of sea walls, using simple technologies such as building of stone walls, may also be considered.

Improved management of marine resources is also important. Education and awareness raising will help people to understand the need for sustainable harvesting and conservation efforts. Education providers such as the Solomon Islands College of Higher Education, the University of the South Pacific and the Secretariat of the Pacific Community should be encouraged to provide training to the communities on sound resource management. The national and provincial governments and the islands' Member of Parliament should also collaborate to enhance the capacity of the islanders so that they are better able to manage their scarce resources in a sustainable way.

Table 12 compares the various adaptation options, their effectiveness, their costs, and their feasibility from technical, social and cultural viewpoints.

Table 12. Summary of the identified adaptation options, their effectiveness and feasibility

Adaptation options	Effectiveness	Costs	Technical feasibility	Social and cultural feasibility	Speed of implementation
Introduce new farming systems, suitable salt tolerant crops and build on existing ACOM FSP	Medium	High	High	Medium	Medium
Traditional food preservation Practices	Medium	Medium	High	High	Medium
Supply of water tanks for rural communities	Medium	Medium	High	High	Medium
Climate change awareness	Low	High	High	High	Medium
Environment and resource management training for communities	Medium	Low	High	Medium	High
Financial literacy training	Medium	Low	Medium	High	High
Improve communications	Low	High	High	Medium	Low
Improve shipping services	Low	High	High	Low	Low
Relocation plan	Low	High	High	Low	Low

7. OBSTACLES TO ADAPTATION

There are three main obstacles to adaptation on Ontong Java atoll.

7.1. Increasing pressure on land

There is a lack of suitable land sites to implement food security and climate change adaptation options, due to an increasing population and an ailing economy. Land scarcity is in some cases contributing to unproductive and unsustainable farming practices.

According to the younger generation on the island, there have been proposals in the past through non-government organisations such as Kastom Gaden and Live and Learn for utilisation of some suitable existing farmland, which is currently used as coconut growing sites. However, the elders are reluctant to give up coconut growing sites for other initiatives because coconut offers an important source of much needed income for the people. This illustrates the competing demands for limited lands coupled with other risks including climate change and associated disasters faced by low-lying atolls such as Ontong Java.

7.2. Lack of information

Lack of information and knowledge on climate change and associated disasters is a major obstacle to the successful implementation of adaptation strategies. The lack of information exists not only at the community level but also at the national level where reliable and up-to-date data and statistics are minimal or absent. Policymakers require these data and statistics to make informed and sound policy decisions.

The lack of information and knowledge reflects a lack of technical capacity on climate change and disaster risk at the national level. Solomon Islands government must give priority to such capacity building, and work with donor partners to develop appropriate training programmes and scholarships on climate change.

7.3. Policy

Currently there are gaps in policy design, strategy setting and effective implementation as far as climate change is concerned. Policies do exist but only at the sectoral level. Public policies that target adaptation at relevant stakeholder levels need to be put in place.

There needs to be mainstreaming of climate change and associated disaster risks policy through the Climate Change Division within the Ministry of Environment, Conservation and Meteorology, and the establishment of a Climate Change Country Team to coordinate all current activities addressing vulnerability and adaptation of sensitive and exposed sectors. Clear strategies must be put in place to map out challenges, solutions and current progress of activities addressing the adverse effects of climate change and sea level rise. The Climate Change Division must be proactive in driving identified solutions and adaptation options.

8. CONCLUSIONS AND RECOMMENDATIONS

The impacts of climate change including climate variability on agriculture, food security, land degradation, forestry, and biodiversity are far ranging. Saltwater intrusion into gardens coupled with coastal inundation and erosion is giving rise to major concerns for people's livelihoods and food security. New sustainable and permanent farming systems need to be designed and developed to enhance the production of food and other livelihood needs. The survey also highlighted other needs for food security, which include transport and communication, and marine resources for deriving income.

Human settlements will be affected by climate change, and especially by sea level rise and coastal erosion. In the household survey 100% of the respondents favoured relocation if the Government offered alternative sites for people to move to. The people also mentioned other options for relocation, including marriage with people on larger islands, and employment and study opportunities for the younger generation as a means of relocation.

People's health is at risk because of contamination of water wells by salt water. Another concern is people's diet. The survey showed that food intake is lacking in protective foods, and growing more vegetables needs to be promoted.

Improved water resources are also needed for livestock and agriculture.

Stakeholders need to work together to address climate change and related disaster risks, in Ontong Java and beyond. Adaptation strategies are needed, backed by supportive government policies. Priority needs for the communities of Ontong Java include financial literacy programmes, climate awareness, education and training, capacity building for agriculture, sustainable environmental stewardship, resource management training and planning, and a phased implementation of relocation options, plans and strategies.

8.1. Recommendations

The following are recommendations for actions that will contribute to climate change adaptation and risk reduction for communities in Ontong Java. These recommendations are cross-cutting or multi-sectoral in nature and their successful implementation requires close collaboration and partnership by all stakeholders.

8.1.1. Short term

- Set up a community-based climate change adaptation and disaster risk management committee for Ontong Java atoll, recognising the partnership and role of church-based and community-based organisations such as mother's union, chiefs and other community leaders.
- Offer a study or look and learn visit to other Pacific island countries and leading institutions to learn about issues such as crops suitable for atoll environment (including salt-tolerant crops) and water management systems and practices.
- Supply water tanks to the communities to address water shortages.
- Authorities should require environmental and social impact assessments as a precondition for approval of projects in the identified vulnerable sectors.
- New initiatives addressing food security should build on the existing foundation set up by the ACOM climate change network, and be carried out in partnership with Malaita NDMO.
- Install meteorological instruments to collect data on rainfall, and use to assist planning by local farmers on when and where to plant their crops.

8.1.2. Medium term

- Undertake demonstration activities in communities of Pelau and Luaniua to improve food production through modifying the soil and food production environment. Measures to include: improved composting techniques; agroforestry; growing vegetables in raised beds and containers; improved home gardening techniques; establishing small nurseries for high quality planting materials; and the introduction of 'soil schools'.
- Advocacy and education on climate change and extreme events and its impacts on people, livelihoods, and the environment.
- Develop and implement new farming methods, and identify and trial new crop varieties and other drought- and salt-tolerant plants and trees that can be used by communities.
- Improve communication to enhance flow of information especially between Honiara and the Atoll. Work with telecommunication companies like Solomon Telekom and Bemobile to expand their services to the two main islands of Ontong Java, to improve early warnings and information dissemination during natural hazards.
- Train and build capacity of multi-sectoral teams who can make regular visits to the islands to carry out assessments, awareness raising and other services.
- Run financial literacy and resource management courses in Ontong Java to enable communities to better manage their money and other resources.

8.1.3. Long term

- Specialised training for identified Ontong Java individuals about climate change vulnerability and adaptation issues, including ecosystem-based adaptation options. Studies and training should be coordinated with the Climate Change Division within the Ministry of Environment, Conservation and Meteorology and involve training institutions such as SICHE through its School of Natural Resources Programme and Rural Training Centres, and NGOs such as Kastom Gaden.
- Promote traditional practices, including agroforestry and food preservation methods.
- Put in place sound biosecurity policy, plans and strategies to control the introduction of new species, and restrict and deal with the movement and proper disposal of invasive species on the islands.
- Encourage voluntary migration through practical means such as the provision of scholarships for young people to relocate for study.
- Commence studies and planning for relocation of communities. This must be done in open consultation with the people of Ontong Java.

8.2. Lessons learned

The V&A study revealed some lessons that could inform climate change adaptation work in the future.

- The church has a lot of influence in the community and should be recognised as a key stakeholder in climate change adaptation efforts.
- Communication and transport play a vital role in food security, and adaptation strategies need to recognise this.
- Marine resources are very important to the people of Ontong Java, providing a lucrative income which is used to ensure food security.
- There is a strong chiefly system on the island, and stakeholder consultations should be in line with this current structure.
- There needs to be close collaboration between the different agencies, such as PACC and the ACOM, and a coordinated approach to adaptation activities, to avoid duplication and misunderstandings.

REFERENCES

Ariki, M. (Ed.) (1997) Initial National Communication. Honiara: PICCAP.

Ballu, V., Bouin, M.-N., Siméoni, P., Crawford, W.C., Calmant, S., Boré, J.-M., Kanas, T. and Pelletier, B, (2011) Comparing the role of absolute sea level rise and vertical tectonic motions in coastal flooding, Torres Islands (Vanuatu). Proceedings of the National Academy of Sciences of the USA, 108 (32), 13019–13022.

Bonie, J.M. (1993) Improved Temotu Traditional Agriculture, Anglican Church of Melanesia (ACOM) Honiara.

Crean, K. (undated) Some aspects of the bêche-de-mer industry in Ontong Java, Solomon Islands. Ministry of Fisheries and Marine Resources, Solomon Islands Government.

Fugui, G. (2008) Ontong Java High Swells assessment report. Ministry of Environment Conservation and Meteorology, Climate Change Department, Honiara.

Hansell, J.R.F. and Wall, J.R.D. (1976) Land resources of the Solomon Islands, Vol. 1: Introduction and Recommendation. Land Resources Division, Ministry of Overseas Development, Surrey, England.

Hiriasia, D (2007) Climate Change and Sea Level Rise in the Happy Isles: Document about the effects of enhanced green house in Solomon Islands. Solomon Islands Meteorological Services, and Solomon Islands Government.

IPCC (1997) The Regional Impacts of Climate Change: An Assessment of Vulnerability (R.T. Watson et al., eds). Cambridge Univeraity Press, Cambridge, UK.

Kauhiona, H. and Fugui, G. (2008) Impact of High Swells and Climate Change on Luaniua and Pelau, Ontong Java Atolls, Malaita Province Outer Islands. Climate Change Division, Ministry of Environment, Conservation and Meteorology, Solomon Islands Government.

Mataki, M., Koshy, K. and Lal, M. (2007) Baseline Climatology of Viti Levu, Fiji and Current Climatic Trends. Pacific Science 60: 49–68.

Natcom (undated) Vulnerability Assessment and Adaptation due to Climate Change: India's Initial Communication to the UNFCCC. Ministry of Environment and Forests, Government of India.

Miller, H.L. (ed.) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

PACC Solomon Islands (2009) Report of in-country consultations. https://www.sprep.org/attachments/Climate_Change/PACC_report_of_in-country_consultations_Solomon_Islands.pdf

PACCSAP Programme (2010) Current and future climate of Solomon Islands. Accessed at www.cawcr.gov.au

Rasmussen, K., May, W., Birk, T., Mataki, M., Merz, O. and Yee, D. (2009) Climate change on three Polynesian outliers in the Solomon Islands: Impacts, vulnerability and adaptation. Geografisk Tidsskrift – Danish Journal of Geography 109(1): 1–13.

Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J. and Dokken D.J. (Eds) (2000) Land Use, Land-Use Change and Forestry. Cambridge University Press, Cambridge.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (Eds) (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Trenberth, K.E., Jones, P.D., Ambenje, P., Bojariu, R., Easterling, D., Klein Tank, A., Parker, D., Rahimzadeh, F., Renwick, J.A., Rusticucci, M., Soden, B. and Zhai, P. (2007) Observations: Surface and Atmospheric Climate Change. In: Solomon, S., Qin, D., Manning,M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. amd Miller, H.L. (Eds) (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 235–336. Cambridge University Press, Cambridge.

Yee, D., Wale, S. and Ariki, M (1999) National Statement on Vulnerability and Adaptation to Climate and Sea-Level Change in Solomon Islands. Ministry of Environment and Conservation, Solomon Islands Government.

APPENDIX 1: VULNERABILITY AND ADAPTATION ASSESSMENT QUESTIONNAIRES

GENERAL INFORMATION

Site name: .....

Village: .....

Date: .....

Facilitator(s): .....

Recorders: .....

.....

.....

Participants: .....

.....

. .....

.....

Focus group discussions goal and objectives

Goal: To determine climate change related hazards, its impacts on the communities and identify potential adaption strategies.

Objectives:

The main objective of the assessment was to conduct a more detailed climate change vulnerability and risk assessments and identify adaptation measures to the impacts of climate change. More specifically to:

a. Assess the degree of vulnerability to climate change on food productions systems in Ontong Java Atoll in relation to climate change risks.

b. Assess food security situation in Ontong Java communities and develop a baseline report on existing vulnerability status of the communities and

c. Identify possible adaptation options, and based on these, to develop a strategy for the PACC demonstration project.

Preamble and questionnaire components

This survey is part of a Project on adaptation of smallholder agriculture to Climate Change funded by the Pacific Adaptation to Climate Change (PACC) Project Funded through UNDP/SPREP and implemented by the Ministry of Agriculture and Livestock (MAL) in partnership with the communities of Ontong Java, Sikaiana and other stakeholders.

The objective of the Project is to improve food production capacity of smallholder communities in areas where agricultural productivity is being threatened by impacts of climate change. We therefore would like to interview you on some topics related to this. Your responses will be held confidential and will help us to assess the current situation of communities, your (communities) awareness of climate change issues/effects, vulnerability of communities to climate change and potential adaptation strategies.

The discussions will be centered on several topics including governance and socio-economic resources, crop production, protein consumption, farming and cropping systems practices, water management, and social cultural factors, emerging issues, access to infrastructure, income generation, major natural emergency events and development. A seasonal calendar exercise will also be undertaken.

Focus Group Discussion Guide

1. Governance and Socio-Economic Resources

a. Demography
   i. How many people live in the community?
   ii. ow many households are there?
   iii. What is the age and gender distribution of the population?

b. Governance and Social Systems
   i. What is the community's management/governance structure? (Differentiate between traditional and modern structures if they co-exist)
   ii. How are the various community leaders and representatives chosen?
   iii. What was the duration of service of the last three village leaders, including the current village leader?
   iv. What is the community's management system?
   v. How many committees are there and what are these?
   vi. What is the community's communications system and dispute resolution system?
   vii. What is the status of community cohesion and collaboration in community activities?
   viii. What types of religion/denominations exist?

c. Human Resources
   i. What types of skilled laborers exist and how many currently reside in the village?
   ii. What types of skilled trades people exist and how many currently reside in the village?
   iii. What types of highly skilled professionals exist (e.g. doctors, engineers etc) and how many currently reside in the village?

d. Resources and Economy
   i. What is the total land area owned by the community and how much of this is 'arable' land?
   ii. How are the resources owned or apportioned to community members?
   iii. If land is communally owned, what is the distribution of land per tribal groupings and what is the land ownership density (e.g. in x tribe, y number of persons per kilometre square)?
   iv. What are the main farming system(s) practiced by the community (e.g. subsistence, semi-commercial, entirely commercial)?
   v. What are the main fisheries system(s) practiced by the community (e.g. subsistence, semi-commercial, entirely commercial)?
   vi. What are the main sources of income?

2. Climate impacts/adaptation

1	Rainfall patterns for the last 10 years	☐ Normal ☐ Frequent ☐ Not frequent
2	Wind	☐ Speed ☐ Direction ☐ Frequency ☐ Seasonal variations
3	What frequency for incursions from natural hazards?	☐ Floods ☐ Storms/hurricanes ☐ Others
4	Have cyclones had impacts on your household /community in living memory?	☐ Yes, major ☐ Yes, minor ☐ No
5	If yes, what were most important impacts Category: 1-strong 2-moderate 3-weak	☐ Agriculture/crops/food availability ☐ Water supply ☐ Housing ☐ Other, specify
6	How did you respond? Category: 1-strong 2-moderate 3-weak	☐ Changed agriculture/crop ☐ Replanted coconuts ☐ Imported ☐ Migration ☐ Repair or build houses ☐ Repair water supply
7	Have periodic droughts had an impact on your household/ community living in memory?	☐ Yes, major ☐ Yes, minor ☐ No
8	If yes, what were most important impacts Category: 1-strong 2-moderate 3-weak	☐ Agriculture ☐ Water supply ☐ Salination and salt intrusion ☐ Other, specify
9	How did you respond? Category: 1-strong 2-moderate 3-weak	☐ Changed agriculture/crop ☐ Imported ☐ Migration ☐ Changed water supply ☐ Other, specify
10	Has flood or intrusion of sea had an impact on your household/ community? Category: 1-strong 2-moderate 3-weak	☐ Agriculture/crops/food availability ☐ Water supply ☐ Salination and salt intrusion ☐ Coastal erosion ☐ Destruction of buildings ☐ Other, specify
11	How did you respond? Category: 1-strong 2-moderate 3-weak	☐ Changed agriculture/crop ☐ Imported ☐ Change water supply ☐ Change location of house ☐ Other, specify

2. Crop production

a. What major staple crops are grown in the area? (Indicate also the # of varieties), rank the crops (Pairwise)

i. Use of field charts to include during the discussion,

ii. Good to include preference of staple crops by the people

iii. Preferences of crops people they do not access

iv. Crops they want to access

b. Food production and Weather patterns (Kaikai Calendar/Months of food shortage & surplus plus Cropping Calendar to be fully stressed)

i. What are the food preservation methods available in your community?

ii. What foods/crops can be preserved?

iii. What are the productivity levels of these crops?

c. Access

i. What is the approximate total size/area of farming land?

ii. What are the predominant land use pattern and systems?

iii. What is the relative soil fertility of the community farm lands?

iv. List, according to importance, the main fish types (non-fin and fin) that are used as food sources

v. What are the productivity levels of these marine/freshwater products?

vi. What is the estimated area of the fishing ground owned by the community?

vii. Do you farm livestock? (If yes, what type and how many?)

viii. Are there any traditional knowledge-based practices that the community uses to manage food resources and ensure food security? (E.g. food preservation or planting techniques,etc.)

ix. Thinking about gender, who accesses and manages these resources?

3. Protein consumption

a. Which meat (protein) is consumed the most in the community?

☐ Fish	☐ Pork	☐ Tin Fish
☐ Shellfish	☐ Chicken	☐ Lamb
☐ Beef	☐ Tin Meat	☐ Wild game

4. Farming and cropping systems practice

a. What do you do when you are making a new garden – in terms of preparing land for gardening?

b. What cropping practices do you have – mixed cropping, mono cropping?

5. Water

a. List, according to importance, the most prominent source(s) of water (e.g. well, spring, borehole, rainwater, stream etc.)

b. What is the water availability throughout the year (e.g. annual rainfall distribution, number of dry months per year, any problems during the dry season or frequency of drought)?

c. What is the water quality of the prominent source?

d. Are there any mechanisms in place to distribute and manage water sources at community level?

e. What are the types and capacities of water storage dedicated for the whole community?

f. What are the types and capacities of water storage at the household level?

g. Thinking about gender, who accesses and manages these resources?

h. Are you aware of cases where there has been loss of soil or erosion due to the effects of water?

i. What do you use the water for?

Use of Water	Sources of Water (tick appropriately)							
	Ground Water (pump)	River	Spring	Well	Rain (Roof Water)	Pipe (Local supply)	Other	Distance*(time)
Drinking								
Cooking								
Laundry								
Hygienic Purposes								
For animals								
Gardening								
Irrigation								
Others								

*Note: *This is the distance between the water source and the farm/garden*

j. What are the main concerns related to water? And why are these, a concern?

- ☐ Quantity
- ☐ Quality (includes salinity)
- ☐ Accessibility
- ☐ Seasonal variation

6. Social cultural factors

a. How does the land tenure system operate in your village?

b. How is the land tenure system affecting your productivity/food security?

c. Do you currently practice local trade or BARTER system involving food exchange?

d. Who is involved in the gardening activities? Division of labor among Men, Women, Children (tick appropriate cells below)

Activity	a) Men	b) Women	c) Boy	d)Girl	e) Others	Who does the most work?
Clearing						
Planting						
Weeding						
Watering						
Harvesting						
Rearing chicken						
Rearing pigs						

e. Do internal conflicts occur in your community? If yes, how do you address

f. If yes, how does it affect your food production and food security?

7. Emerging issues

a. Are there environmental issues in the community? If YES, what are these issues?

b. Waste management systems/ how do they use the wastes?

c. How is the community addressing the environmental issues?

d. What is the health's related issues affecting people in the community?

i. Lists those issues

ii. What particular problems do they face in food production and utilization?

e. Are there disabled members of the community living in your village? If YES, what particular problems do they face in food production and utilization? Other vulnerable groups in the community or people with special needs.

8. Access to infrastructure

a. Tick those infrastructures that the community can access.

- ☐ Generator
- ☐ Paved Road
- ☐ Mobile Phone Provider
- ☐ Small Boats
- ☐ Bush Road
- ☐ Solar Power
- ☐ FM Radio
- ☐ Store
- ☐ Ships
- ☐ Gravel Road
- ☐ Electricity
- ☐ AM Radio
- ☐ Diesel/Zoom
- ☐ Trucks
- ☐ Land Line Telephone
- ☐ Television/DVD
- ☐ Schools
- ☐ Clinics/Healthcenters

b. Write the name and distance of the nearest infrastructure/service

		Name	Estimate Distance (KM or time)
1	Urban Area		
2	Provincial Centre		
3	Airport/Airstrip		
4	Wharf		
5	Aid Post/Health Centre		
6	Hospital		
7	Primary School		
8	Secondary School		
9	Rural Training Centre		
10	Agriculture Office		
11	Market		

9. Income generation

a. What major activities are happening around the community in which some members of the community are engaged in for income earning purposes?

Activity	Details
Agriculture (copra and vegetables)	
Fishing/ other marine products	
Tourism	
Handicrafts	
Transport	
Livestock	
Forestry	
Others	

10. Major natural emergency events

a. Tick the box for the event that has happened in the last 5 years and write down the years (s)

- ☐ Earthquake
- ☐ Landslide
- ☐ Heavy Rain
- ☐ Drought
- ☐ Acid Rain
- ☐ Tsunami
- ☐ Cyclone
- ☐ Flood
- ☐ Volcanic Eruption
- ☐ Other Major Events

11. Development plans

a. Are there any village development plans or community investment/business plans? (If yes, was any training provided or financial assistance received?)

b. Are there any plans relating to the development or management of natural resources? (If yes, was any training provided or financial assistance received?)

c. What projects have been implemented in the last 30 years? (If yes, have these been implemented by the community or through external assistance?)

d. Has a climate change adaptation project been implemented by the community?

e. What in-kind contribution would the community be willing to provide for this project?

f. What cash contribution would the community be willing to provide for this project?

APPENDIX 2: WORKSHOP PROGRAMME

Day 1

DAY SESSION

1. Opening Prayer
2. Introduction of the team
3. Brief on PACC project (PACC SI, UNDP, GEF, AusAID)
4. Purpose (V&A assessment) and program of our visit. Based on the findings of this V&A assessment the core problems will be analyzed and define (record of vulnerabilities, propose adaptation measures, develop adaptation plan).
5. Conduct Assessments-Focus groups (refer focus group guide)
   - Ask these groups about their perception on climate change (to be written on butcher paper with label)
   - For the same group ask them how they prepare themselves for climate variability (cyclones, sea level rise, salt water intrusion, food damages especially for food security - *traditional knowledge*). (Written on separate butcher paper with label)
   - For the same group ask any major changes in the environment such as invasive species, loss of certain important plants or animals, changes to shoreline and coast, salt water intrusion (written on separate butcher paper with label)
6. Take photos of community participation, and butcher paper before folding them.

EVENING SESSION

1. Divide community in groups: elderly men, youth and women with head counts
   - Governance and Socio-Economic Resources
2. Take photos of community participation, and butcher paper before folding them.
3. Climate change video clips in the evening.
4. Take photos of community participation, and butcher paper before folding them.

Day 2

DAY SESSION

1. Brief presentation on climate change (what are the facts and why adapt)
2. Importance of physical environment, forests and agro-forest, sea reef
3. Focus group discussion
   - Crop production
   - Protein consumption
   - Farming and cropping systems practice
   - Water
4. Take photos of community participation, and butcher paper before folding them.

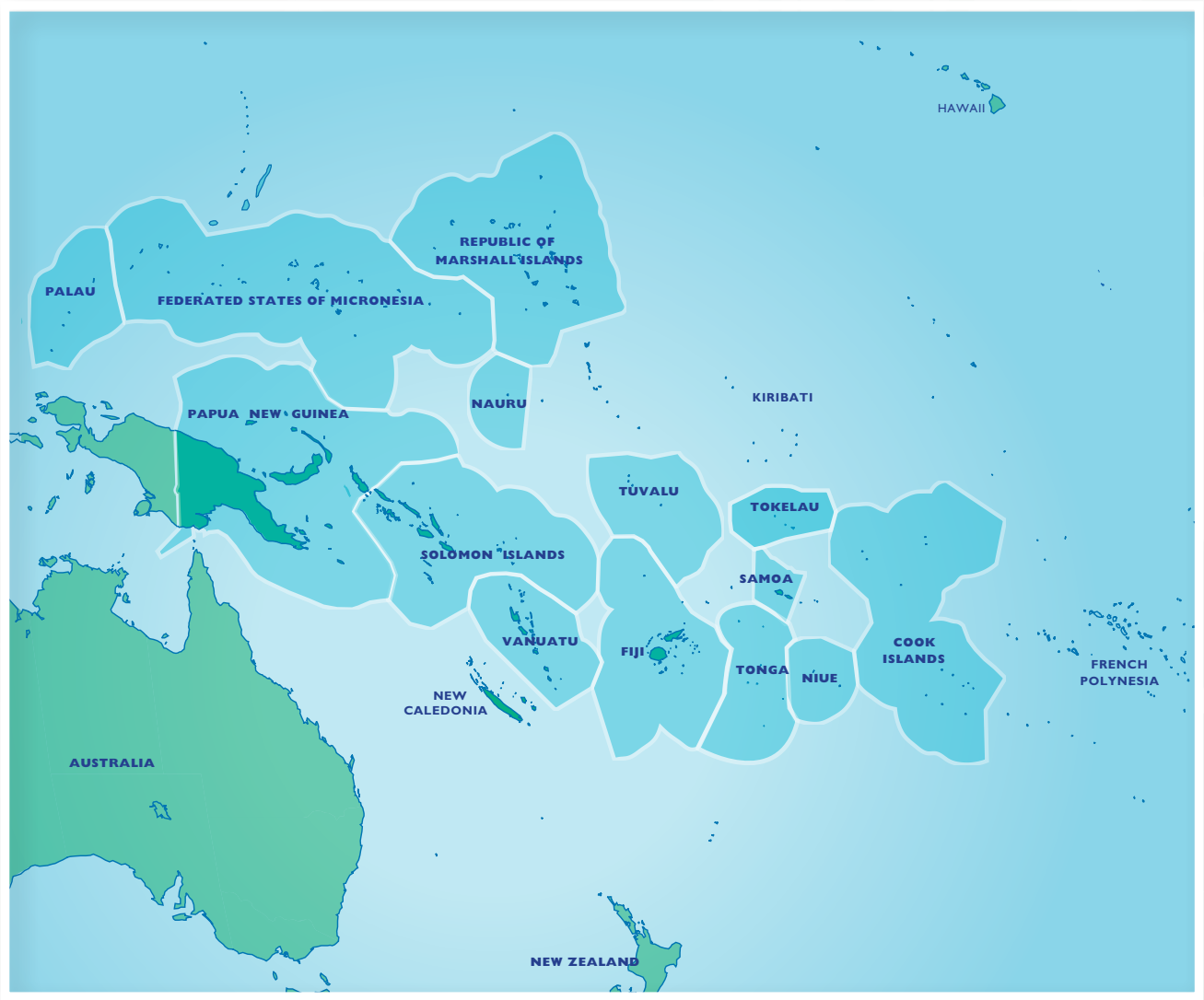
EVENING SESSION

1. Focus group discussion Social cultural factors
   - Emerging issues
   - Access to infrastructure
   - Income generation
2. Take photos of community participation, and butcher paper before folding them.

Day 3

DAY SESSION

1. Focus group discussion
   - Income generation
   - Major natural emergency events
   - Development plan
2. Take photos of community participation, and butcher paper before folding them.
3. Conclusion of our findings and way forward
4. Pack ready for ship



PACC – building adaptation capacity in 14 Pacific island countries and territories

PACIFIC ADAPTATION TO CLIMATE CHANGE (PACC) PROGRAMME

The PACC programme is the largest climate change adaptation initiative in the Pacific region, with activities in 14 countries and territories. PACC is building a coordinated and integrated approach to the climate change challenge through three main areas of activity: practical demonstrations of adaptation measures, driving the mainstreaming of climate risks into national development planning and activities, and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. PACC began in 2009 and is scheduled to end in December 2014.

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PACC TECHNICAL REPORTS

The PACC Technical Report series is a collection of the technical knowledge generated by the various PACC activities at both national and regional level. The reports are aimed at climate change adaptation practitioners in the Pacific region and beyond, with the intention of sharing experiences and lessons learned from the diverse components of the PACC programme. The technical knowledge is also feeding into and informing policy processes within the region.

The Reports are available electronically at the PACC website: www.sprep.org/pacc, and hard copies can be requested from SPREP.

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