Social and economic assessments of climate change adaptation in the Pacific: Making informed choices




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Acronyms

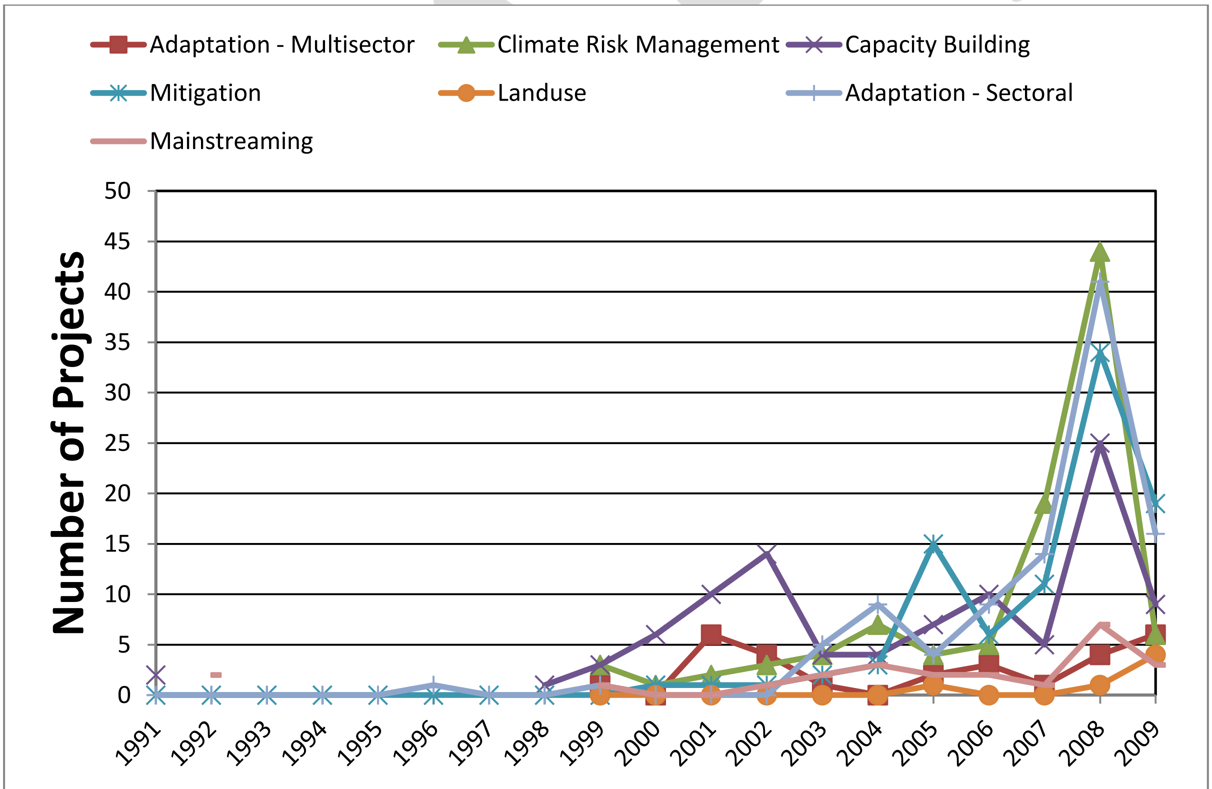
Executive Summary

1. Background

In response to the increasing impact of climate change, countries in the Pacific have implemented a number of climate change adaptation measures over the last two decades. These range from activities that focus on mainstreaming climate change into national and sectoral level policies, plans and strategies to actual on the ground projects. This range of work implemented also includes a number of climate and weather related disaster risk management (DRM) initiatives and projects that may not explicitly been categorised as CCA (Figure 1).

Many of these projects were implemented with financial and technical support of development partners on a bilateral or multilateral basis, with approximately 500 projects costing US $1860 million supported between 1991-2009. These projects covered a variety of themes such as climate risk management, mainstreaming, land use and sectoral adaptation activities.

Figure 1.1 CCA Initiatives in the Pacific, 1991-2009



Source: Hay (2009a).

The majority of the regional CCA projects implemented in the Pacific in recent years have focused on capacity building in one way or the other; for example:

- institutional strengthening for improved decision-making[1];
- policy development and planning (based on various regional projects funded by AusAID, EC, UNDP, ADB, and the World Bank)[2];
- support to the development of National Adaptation Plans of Action (NAPA) (and National Action Plans for disaster risk management);
- development of national and/or sectoral policies;
- downscaling of climate change modelling predictions, (PI Climate Prediction project of AusAID); and

The few on-the-ground projects have mainly targeted community-based activities, such as water storage facilities, shoreline protection through mangrove replanting and trialling of versatile crop varieties, which mainly focussed on addressing current disaster risk deficits. Countries within the Pacific have increasingly been requesting the focus to be shifted to more tangible and practical on—the-ground adaptation projects be undertaken targeted at local level vulnerabilities, rather than just developing policies and plans (Morrell 2009).

In response, there has been an increase in the number of actual projects including projects currently underway such as:

- the first regional UNDP-GEF funded Pacific Adaptation to Climate Change (PACC) project in 14 countries executed by SPREP across 14 countries and covering core sectors such as coastal zone/ infrastructure, water security and food security;
- climate proofing of the Western Guadalcanal road in the Solomon Islands by the Asian Development Bank (ADB);
- the construction of reservoirs and water tanks across eight Pacific Island Countries (PICs) to increase water security, funded by the European Commission and executed by SOPAC; and
- introducing climate-resistant crops, breeding extreme weather- adapted livestock, developing community land-use plans, trialling new agroforestry and soil stabilisation methods, and undertaking innovative climate adaptation education programmes in Vanuatu executed by SPC-GIZ under the German Government Funding.

There are also other food security related projects implemented by the Centre for Pacific Crop and Trees (CePaCT) that focused on producing salt and drought resistant crops that are salt and pest and disease resistant that help address current development needs but which could also serve to reduce future climate risk (see:http://www.spc.int/lrd/index.php?option=com_content&view=article&id=630:climate-ready-collection&catid=66:centre-for-pacific-crops-and-trees&Itemid=26).

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[1] See e.g. GIZ project on *Coping with climate change in the Pacific Island Region (CCCPIR);* http://www.spc.int/lrd/index.php?option=com_content&view=article&id=478&Itemid=44

[2] See e.g. (www.bom.gov.au/climate/pi-cpp; www.ausiad.gov.au/country/pacific; www.csiro.au/parntership/Pacific-Cliamte-Change-Science-Program.htm; www.adaptationlearning.net/program/programmes-water-safety-plans-pdms), ADB (www.adb.org/projects/project.asp?id=41187); www.thegef/sites/thegef.org/files/documents/document/09-16-08-SCCF.pdf)

Although some of these projects have produced, or promise to produce, good localised benefits, some countries and donors have often had difficulty in sustaining such benefits, and/or scaling up the activities to generate country-wide benefits. It is unclear if recent and ongoing progress in disaster risk reduction will be sufficient to protect people and properties from future increases in number of potentially disastrous events brought about by a combination of climate variability and change (Hay and Mimura 2010)).

The success of adaptation options critically relies not only on understanding the nature of climate change challenges and drivers of vulnerability and available adaptation options, but also on robust decision-making processes and framework adopted to make informed choices. A robust and practical decision-making framework that recognises current data and capacity constraints in the PICs is required to support countries in their adaptation decision-making. It is essential that this framework is supported by the best available scientific and traditional knowledge, as well as experiential knowledge of dealing with climatic disasters (Wickham, Kinch et al. 2009).

In this context, the Australian Government is implementing the Pacific Adaptation Strategy Assistance Program (PASAP) under its International Climate Change Adaptation Initiative program in Asia-Pacific. The PASAP is intended to strengthen partner country capacity to assess vulnerability to climate change and develop evidence-based adaptation strategies. A key element of the PASAP is a regional overview that describes regional trends and variability in climate change impacts, vulnerability and adaptive capacity, and identifies common needs. The overview is also expected to synthesise existing knowledge about adaptation in the region, identify both lessons learned and relevant good practice measures and significant knowledge/ research gaps.

As part of this regional overview, the Australian Government has commissioned the International Union of Nature Conservation, Oceania Regional Office (IUCN-ORO) to undertake research on how the economic and social costs and benefits of adapting to climate change are currently considered in decision-making at the national, sub-national and or community levels in the Pacific. The research is implemented in partnership with SOPAC (a now Applied Geosciences and Technology Division of SPC/ SOPAC).

DCCEE-IUCN Project Objectives

The basis of the specific objectives of this DCCEE-IUCN economics and governance project is on a review of international and regional literature and a selected number of case studies

The specific objectives of the economics and governance project are based on a review of international and regional literature and a selected number of case studies, and aims to provide:

- analytical framework (s) suitable for assessing economic and social costs and benefits of climate change adaption projects in the Pacific;
- an overview of key constraints in undertaking economic and social assessments-based informed choices about climate change adaption project in the Pacific; and
- suggestions for overcoming key institutional and other constrains in the use of economic and social assessment in making informed choices about CCA in the Pacific.

Four case studies (Table 1.1) were selected to reflect priority climate change adaptation issues in the Pacific:

- food security and crop improvement;
- water security;
- relocation; and
- infrastructure.

Table 1.1: Case studies selected for detailed country level assessment

Climate Change Adaptation Issue	**Title of case study**	Country
Food security and climate resistant crops	Germplasm conservation and crop improvement : BCA of regional germplasm collection & crop improvements for commercial and/or subsistence purposes	Samoa and Vanuatu
Water security	Improved rainwater harvesting and conservation projects and enhanced human sanitation system	Tuvalu
Relocation/ resettlement/ migration	Climate change related relocation of Lateu village, Lirak Island	Vanuatu
Climate proofing of infrastructure projects	Solomon Islands Road Infrastructure Improvement Project (SIRIP), Western Guadalcanal	Solomon Islands

The report is structured as follows.

Chapter 2 provides a brief overview of climate-related disasters and climate change risks in the Pacific, summarises current knowledge about Pacific specific climate change scenarios, and outlines expected changes in climatic disasters and vulnerabilities in the Pacific island countries. The brief overview is provided here to contextualise discussions to follow in Chapter 3-6; however, it would need further discussion, beyond the scope of this report, to make it comprehensive.

Chapter 3 examines the conceptual frameworks for making social and economic assessment based decisions about adaptation to climate change, using policy and project cycle-based decision-making context. It also highlights practical challenges in using economic cost benefit analysis to underpin policy, program and project choices.

Chapter 4 discusses the four illustrative case studies from the Pacific region to the highlight key issues, challenges and areas for strengthening to make economic and social assessment based adaption decisions. Detailed case studies on which this chapter draws on are contained in a compendium volume.

Chapter 5 gives a summary of a review of recent efforts made to provide economic and social assessments at project and national/ sectoral planning levels (Section 5).

Chapter 6 then draws on Chapters 3, 4 and 5 to identify practical steps towards strengthening economic and social knowledge based climate change adaptation choices.

2. Climate change risks in the Pacific

Global warming is now recognised as the major factor accentuating climate regimes and normal variations due to El Nino Southern Oscillation (ENSO). ENSO is a natural cycle of the climatic system, characterised by distinct patters of changes in features such as winds, surface pressures, sea temperatures, and precipitation. Historically, El Nino events have been correlated with moderate to extreme drought conditions, while La Nina events are associated with wetter spring and summers. It is, however, difficult to distinguish between the effects of ENSO, the longer term interdecadal change, and those associated with anthropological climate changes. Nonetheless, it is certain that natural variability in climatic conditions and extreme events will be compounded by climate change and sea level rise over time (BOM and CSIRO 2011 (draft)), increasing vulnerability of the Pacific countries

Pacific island communities are amongst the most vulnerable to climate change in the world, facing regular climate related disaster risks. Disaster risk is defined by the interaction between hazard, exposure of social, economic and environmental elements and the properties of the exposed systems – i.e., their sensitivity of social, economic and environmental systems. ISDR notes that disasters, development and environment are inextricably linked (ISDR 2004). The “big ocean, small islands” context of the Pacific Island contributes (PICs) to the environmental and economic exposure and risks of these nations and communities to natural disasters. PICs, many of which are located along the equatorial belt, are regularly exposed to and experience climate and hydrometeoroloigcal hazard conditions, including cyclones, high winds, flooding and storms (Table 2.1); hazard being defined as ‘a potentially damaging physical event, phenomenon or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation’ (p. 16, ISDR 2004).

Table 2.1 Some example of the nature of risks to climate related disasters faced in the Pacific region

Country	Cyclone flood	Coastal flood	River flooding	Drought	Storms	landslide
Fiji	H	H	H	M	H	H
FSM	M	H	L	H		L
Kiribati	L	H	Na	H	M	L
Marshall Islands	na	M	H	na		L
Solomon islands	H	H	H	L	H	H
Tonga	H	H	M	H	M	L
Tuvalu	L	H	na	M	L	L
Vanuatu	H	H	H	L	H	H

H – high; M – medium; L – low; na – not applicable
Source: Adapted from United Nations Department of Humanitarian Affairs (1994).

The relationship between development and disasters is well known (eg. UNDP 2004; Wisner 2004), and PICS are particularly vulnerable to the effects of climatic conditions because of their limited development and weakening traditional lifestyle (Wikcham et al 2009). Their vulnerability is heightened because of their reliance on the climate sensitive primary sectors, such as agriculture for basic livelihood and income, limited alternative sources of income, low human development conditions (such as household income, access to water and sanitation), and limited financial and human capital. Climate change is projected to exacerbate these disaster risks.

Climate change projections

Weather, climate and ocean current patterns in the Pacific are a product of both natural and human induced climate change. Natural factors include trade wind regimes, South Pacific Convergence Zone, with El Nino Southern Oscillation (ENSO) as the dominant force affecting annual variability. The WGII report to the Fourth Annual Assessment Report (AR4) of the IPCC (Mimura, Nurse et al. 2007) note the following climate changes for the Pacific region, based on global climate modelling:

- Annual and seasonal ocean surface and island air temperature have increased by 0.6 –1.0°C since 1910 throughout a large part of the region southwest of the South Pacific Convergence Zone and projected to further increase over time;
- More hot days and warm nights, and significantly fewer cool days and cold nights, particularly in years after the onset of El Niño events;
- Analysis of satellite and tide gauge data show a maximum rate of sea level rise in the central and eastern Pacific, spreading north and south around the sub-tropical gyres of the Pacific Ocean near 90°E, mostly between 2 and 2.5 mm/year, peaking at over 3mm/year for the period 1950–2000; and
- Differential changes in average precipitation are also expected with some islands showing drier conditions while other areas are projected to experience increased average rainfall, as well as extremes.

Under the Pacific Climate Change Science Program (PCCSP), the Australian Bureau of Meteorology (BOM) and the CSIRO have identified 24 global climate models (GCM) (BOM and CSIRO 2011 (draft)). BOM and CSIRO acknowledge that these models do not explicitly represent the situation faced in the Pacific islands, noting that that while they can simulate broad scale Pacific climate conditions, they cannot account for local climate effects resulting from island shapes and topography. With constraints in computational resources and lack of available data, only 6 of the 24 GCM could be downscaled for use in the Pacific region with any degree of confidence (BOM and CSIRO 2011 (draft)).

Using downscaled global climate models, BOM and CSIRO's latest results suggest that projected changes in mean climate conditions are expected to remain small (Figure 2.1), while significant shift is expected in the extreme events, including

  - The number of days of heavy rain is projected to increase in all locations, except for those areas where annual mean rainfall are projected to decrease; and
  - The proportion of cyclones with higher intensities is expected to increase, although overall, the Pacific region is expected to see a decrease in the number of cyclones (10-50% decrease).

Countries in the region are also expected to experience different climate conditions, such as changes to surface temperature and rainfall (summarised in Figure 2.1 for case study countries discussed in Chapter 4), suggesting a need to look at local climatic scenarios when predicting projected changes in disaster risks.

Taking natural and human-induced climatic forces and dynamics into account, BOM and CSIRO provide likelihood estimates associated with different climatic futures, recognising inherent uncertainties (Figure 2.1). For example, the Solomon Islands can expect to see (with a likelihood of 77%) little change in their average rainfall pattern, but at the same time there is a 22% chance of getting slightly wetter conditions (Figure 2.1 b). In comparison, Tuvalu can expect a 50% chance of experiencing wetter conditions (Figure 2.1 c). Such likelihood projections of climate futures, as discussed in Chapter 3, are required in assessing costs and benefits of climate change adaptation measures together with estimates of the value of damages and losses due to climate changes on people and society.

Impacts

With global warming, countries and communities are projected to experience changes in their hazard and risk profiles. Such changes could include(Prabhakar et al 2009):

- Changes in the kind of disasters that is experienced (from no disasters in the past to more disaster events);
- Changes in types of hazards (from floods to more droughts); and/or
- Change in hazard intensities and magnitude.

Such changes in disaster risks may arise from changes in one or more climatic conditions and may manifest themselves through multiple pathways, ultimately affecting human well being (Figure 2.2). Decreased precipitation lasting for extended periods of time, for example, could result in drought conditions. Whether these are due to long term human induced climate changes of climatic variability due to ENSO events, or events compounded by climate change, such events have both direct and indirect impacts on human well being. The ENSO associated droughts in 1998-2000, for example, resulted in serious water shortages across much of the region, including PNG, RMI, FSM and Samoa. A national emergency was declared in FSM in 1998 when 40 atolls ran out of water, while RMI imposed severe water rationing and constructed desalination plants to provide some much needed access to drinking water.

Figure 2.1 Climate Future Projection for Annual rainfall and Annual Surface Water for 2030 using A2 emission scenario (Source: BOM and CSIRO 2011 (draft))

a. Samoa

Climate future for 2030 using the A2 emission scenario

		Annual Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)	Much Drier < -15.00				
	Drier -15.00 to -5.00		Likelihood: 2 of 18 models (11%)		
	Little Change -5.00 to 5.00		Likelihood: 13 of 18 models (72%)		
	Wetter 5.00 to 15.00		Likelihood: 3 of 18 models (16%)		
	Much Wetter > 15.00				

- Most likely future: warmer with little rainfall change (CSIROMk3.5 model)
- Largest change future: warmer and wetter (HADGEM model)

b. Solomon Island

Climate future for 2030 using the A2 emission scenario

		Annual Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)	Much Drier < -15.00				
	Drier -15.00 to -5.00				
	Little Change -5.00 to 5.00		Likelihood: 14 of 18 models (77%)		
	Wetter 5.00 to 15.00		Likelihood: 4 of 18 models (22%)		
	Much Wetter > 15.00				

- Most likely future: warmer with little rainfall change (CSIROMk3.5 model)
- Largest change future: warmer and wetter (HADGEM model)

c. Tuvalu

Climate future for 2030 using the A2 emission scenario

		Annual Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)	Much Drier < -15.00				
	Drier -15.00 to -5.00				
	Little Change -5.00 to 5.00		**Likelihood: 9 of 18 models** (50%)		
	Wetter 5.00 to 15.00		**Likelihood: 9 of 18 models** (50%)		
	Much Wetter > 15.00				

- Most likely future: warmer with little rainfall change (GFDL2.1 model)
- Largest change future: warmer and wetter (ECHAM5 model)

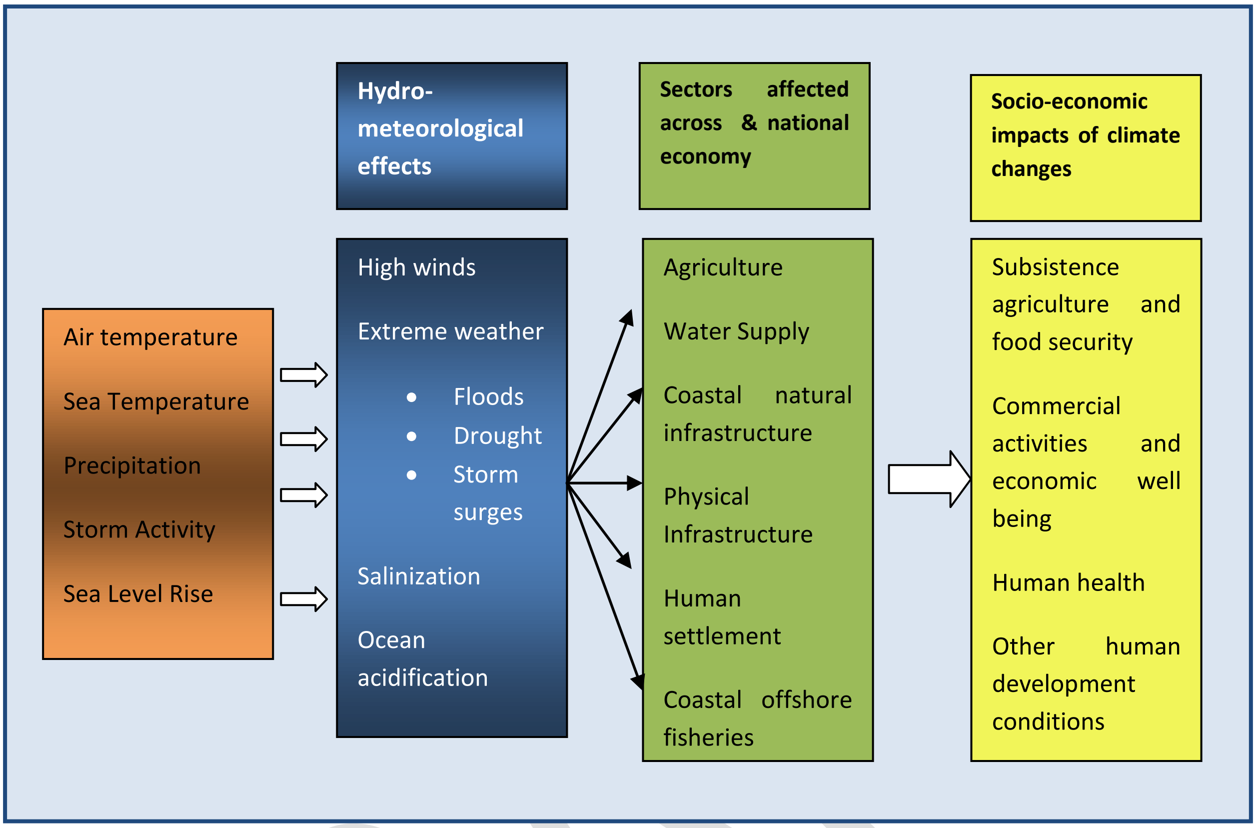
d. Vanuatu

Climate future for 2030 using the A2 emission scenario

		Annual Surface Temperature (C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Annual Rainfall (%)	Much Drier < -15.00				
	Drier -15.00 to -5.00		**Likelihood: 4 of 18 models** (22%)		
	Little Change -5.00 to 5.00	**Likelihood: 1 of 18 models** (5%)	**Likelihood: 11 of 18 models** (61%)		
	Wetter 5.00 to 15.00		**Likelihood: 2 of 18 models** (11%)		
	Much Wetter > 15.00				

- Most likely future: warmer with little rainfall change (CSIROMk3.5 model)
- Largest change future: warmer and drier (GFDL2.0 model)

Figure 2.2 Climate change, their hydro meteorological effects, sectors that may be affected and the social and economic impacts on people



The availability of water affects the level of human hygiene, although acknowledging that the relationship can be mixed. Singh et al (2004) found that in low-atoll islands, such as Tuvalu and Kiribati, there is a strong correlation between climate variability and rates of diarrhoea. In Tuvalu, for example, after heavy rains, the economic cost on the island can be as high as $AUD500,000 because of flooding induced pollution from septic tanks and its effects of water borne illness and drinking water (Lal, Saloa et al. 2006). By comparison in Vanuatu, increased incidence of diarrhoea and skin diseases and malaria was directly associated with high rainfall and/or storm surges (Nakalevu and Phillips 2007). After five cyclonic events in 2002-2003, Vanuatu reported increase in malarial incidence by 50% and in the water borne diseases by almost 100% when compared to the same period in 2001-2002(Lal, Wickham et al. 2009).

Same climate factors can affect multiple sectors and the effects of climate can change can be further magnified. For example, increased precipitation can have a positive and negative effect on agricultural production at the same time human health, affecting productivity and human suffering (see Table 2.2).

Similarly changes in temperatures and rainfall directly can have both positive and negative impacts. Slight increases in climate conditions at the right times, such as rainfall, can increase crop yields and agricultural output. These changes could also result in the increase in the spread of pests and diseases, such as taro leaf blight experienced in PNG and Samoa. Other changes in climatic conditions, such as flooding and cyclones, can drastically reduce agricultural output, with major economic costs to society (summarised in Figure 2.3). However, as the effects of climate risks manifest themselves through multiple pathways, the impacts are not always easy to predict with certainty without sound scientific and or experiential knowledge.

Figure 2.3 Climate change effects and pathways of impacts on agricultural production and food security

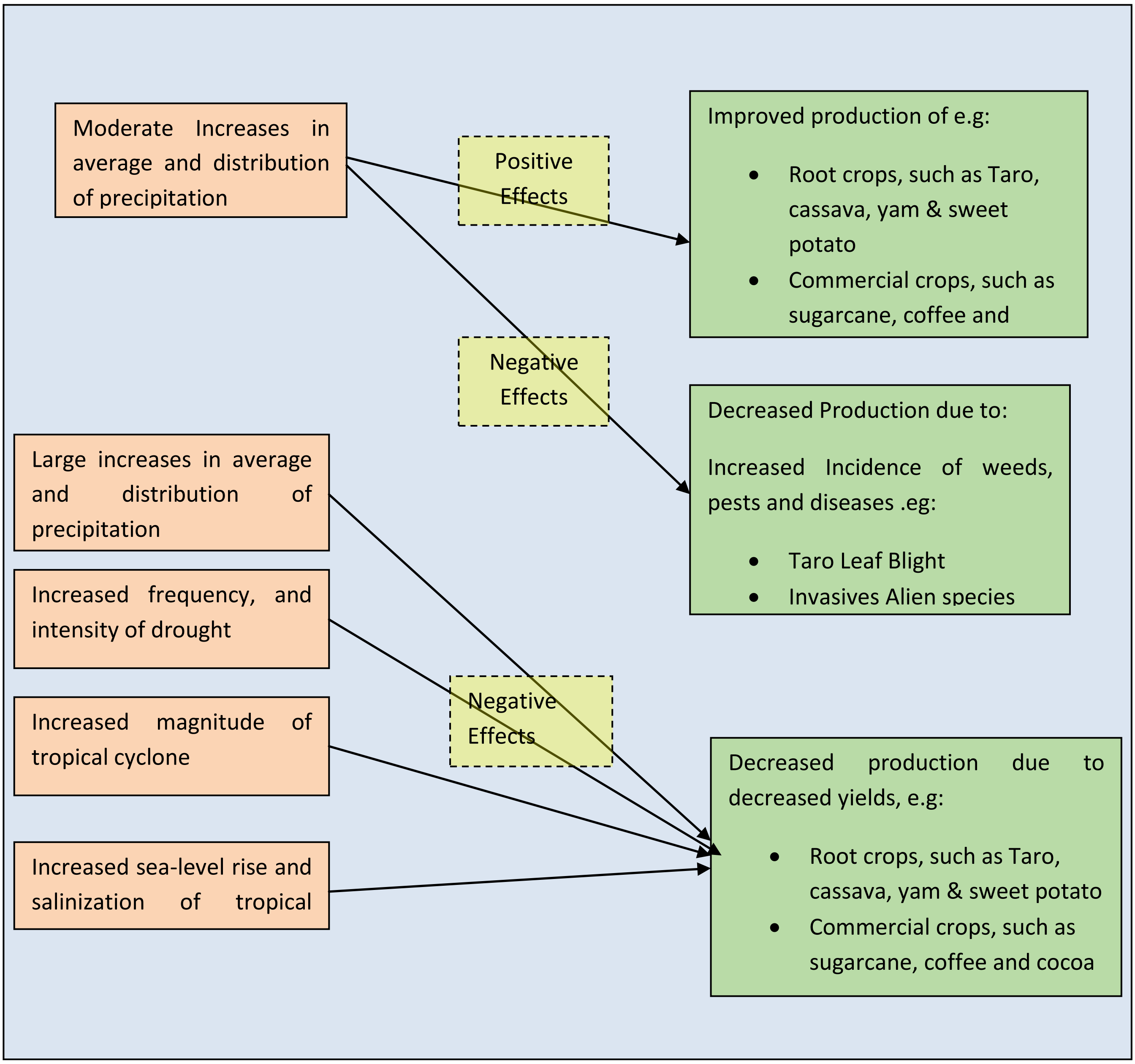


Table 2.2 Climate change and expected impacts on agriculture, water, coastal zone and infrastructure sectors

	Agriculture and Food security	Water (Quantity and Quality)	Coastal Zone & Human Habitation	Infrastructure
Increased precipitation	• Flooding of agricultural lands and crop damage • Create favourable conditions for growth of less invasive species; • Create conditions favourable for spread of pest and diseases	• Alleviate water shortage especially on small islands • Flooding and pollution of underground water sources and coastal areas; • Flooding and causing water and insect borne disease	• Coastal flooding	• Flooding damage to roads, bridges
Decreased Precipitation (and increased temperature) - (drought conditions	Decrease in crop yield and production: • Plant and animal stress; • Water shortages for agriculture purposes; • Affect health, production and reproductive capacity of animals; • Slow growth and low yields from food crops;	• Increased water shortage especially on small islands • Water shortage and associated sanitation issues, causing water borne diseases		
Cyclones	• Wind damage to agricultural crops and forest trees; • Erosion of coastal areas due to wave surges and flooding; • Damage to crops from salt spray and rising sea levels; • Loss of animals due to falling coconut trees; • Outbreaks of invasive species;	• Inundation of groundwater sources; by salt water; • Destruction of farm rainwater storage facilities; • Flooding and pollution of underground water sources and coastal areas; • Flooding and causing water and insect borne disease	• Coastal flooding, damage to homes and property	• Flooding damage to roads, bridges

Sea Level rise	• Salt water inundation and flooding of coastal agricultural lands; • Erosion of soil and coastal areas; Increase salinity of agricultural lands	• Inundation of coastal springs and underground water sources;	• Coastal flooding and damage to homes and property • Coastal inundation and forced relocation	• Coastal inundation and damage to roads, ports and other infrastructure
Source: Based on World Bank (2000) and FAO (2008).				

The impact of climate-related disasters is felt across the economy, as well as locally by the people. Between 1950 and 2009, Pacific island countries experienced over 200 declared climate disaster events, causing a damage of approximately US$ 6.5 billion (Hay and Mimura 2010). The majority of damage was caused by cyclones (storms), which caused almost 95% of all climate related damages in the region (Table 2.3). However, such disaster statistics though do not include estimates of crop losses due to pest and disease outbreaks, many of which are also very climate dependent. In terms of national GDP, such costs on average was equivalent to 2-7% of countries GDP (Word Bank 2000), with individual disasters causing a damage equivalent of 200% of their annual GDP in Niue following cyclone Heta in 2004 (McKenzie et al. 2004).

Table 2.3 Frequency and reported economic and social impacts of natural disasters in the Pacific

Type	**Number**	**Killed**	**Total Affected**	**Total Victims**	**Economic Damage**	**No of events with reported economic damages**
Drought	8	60	947,635	947,635	66,666,667	1
Epidemic	12	306	10,662	10,968	-	0
Flood	28	132	451,073	451,205	264,339,362	11
Landslide	16	544	2,563	3,107	-	0
Storm	134	1573	1,937,467	1,939,040	6,128,846,865	57
Surge	4	2534	11,574	14,108	-	0
Wild fire	2	0	9,000	9,000	67,340,426	1
Climate related total	204	5149	3,369,974	3,375,063	6,527,193,320	70
Total (all disasters)	250	8297	3,611,773	3,620,070	6,892,230,514	78
%	82%	62%	93%	93%	95%	90%
Source: Hay and Mimura (2010).						

In 2004, for example, after Cyclone Ivy, Vanuatu reported damages of about US$12 million, affecting 50,000 people, 90% of water resources, 70% of roads, and 60% of all health infrastructure was affected, together with the damage of about 80% of the food. In Fiji, for example, Cyclone Amy is reported to have caused a direct agricultural loss of about FJD 66 million (approximately US$29 million) (McKenzie, Prasad et al. 2005).

With much of the PICs reliant on locally grown rain-fed crops for their energy and protein, current disaster risks also have significant effects on household livelihood. For example, in the Solomon Islands, cyclones in 1985 and 1986 are reported to have caused significant food shortages in the

Weathercoast Communities of Makira. Such events have been regular enough to have impacted on the society and culture, with locals talking about *time blong hungry* (Jackson, Tutua et al. 2006).

However, as the effects of climate risks manifest themselves through multiple pathways, the impacts are not always easy to predict with certainty, without sound scientific and/or experiential knowledge. Recent experience with changing weather and climate, Pacific communities are already observing changes in their crops with much change believed to have occurred in the last decade. Included in the community perception of climate change (BOM and CSIRO 2011 (draft)) of climate change are:

- More frequent and extreme rainfall causing flooding and mudslides;
- More drought and fires;
- More hot days;
- Shifts in seasonal patterns of rainfall and tropical cyclone;
- An increased incidence of certain weeds, pests and diseases outbreaks (such as taro leaf blight); and
- Increased storm surges, causing coastal erosion, saltwater contamination of freshwater springs and taro swamps.

Based on their past experiences and recent observations, PICs acknowledge their vulnerability and have identified key sectors of particular concern, including agriculture (food security), water (water security and human heath particularly from water and water dependent insect borne diseases), infrastructure (flooding and sea level rise), and the coastal zone (sea level rise and human settlement (Table 2.4). Such assessments were carried out as part of the National Communication reports to UNFCCC and assessments done for national adaptation plan of action (NAPA) in the least developed countries, and other national assessments.

Table 2.4 Priority Sectors of Concern in Pacific Island Countries

Country	Agriculture	Water (water security)	Water (Flooding)	Health (water & insect borne	Fisheries	Road & Ports Infrastructure	Coastal Zone SLR, and human settlement)	Key Sources
Cook Islands	✓	✓			✓	✓	✓	1
Federated States of Micronesia		✓					✓	2
Fiji		✓	✓	✓	✓	✓	✓	3
Kiribati		✓		✓			✓	4
Marshall Islands		✓			✓		✓	5
Nauru		✓		✓			✓	6
Niue	✓	✓		✓	✓		✓	7
Palau	✓	✓		✓	✓		✓	8
PNG	✓	✓		✓			✓	9
Samoa	✓	✓		✓			✓	10

Solomon Islands	✓	✓	✓	✓	✓	✓	✓	11
Tonga	✓	✓		✓	✓		✓	12
Tuvalu	✓	✓	✓	✓	✓		✓	13
Vanuatu	✓	✓		✓	✓	✓	✓	14
Sources: to complete								

With such projected impacts across the economy, countries also recognise that adaptation to increasing and changing risks would need to be tackled across sectors, and the measures would need to be multidimensional and multifaceted, as discussed in the next chapter. In making appropriate risk management decision (s), as discussed in Chapter 3, economic and social assessment of current risks and projected risks under climate change, as well as the costs and benefits of alternative adaption measures, can help decision-makers to make informed choices, using appropriate information about climate change scenarios with associated likelihoods.

3. Economic and Social Assessment of Climate Change Adaptation: A conceptual framework

With the changing disaster risks due to climate change, there is an increasing acknowledgement of the need for improved disaster risk management not only to address current risks, but also risks heightened through climate change. Risk management is defined as the implementation of strategies to avoid unacceptable consequences and risk management strategies in the context of climate change comprise, climate change adaptation and mitigation (Pittock 2003). The focus of this report is on adaptation.

While adaptation to climate change has been variously defined (Box 3.1) to reflect 'adjustments', a process, a set of 'practical steps' to achieve some pre determined goal, or even an 'outcome', it is essentially about managing climate change related risks. This may include adaptation of natural systems as well as those of human systems, as well as emphasise institutional/policy dimensions (Levenia and Tirpak 2006). In the Pacific, all these different dimensions of the term adaptation are relevant.

Box 3.1: Different definitions of the term Climate Change Adaptation

Adaptation – *Adjustment in natural and human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities* (IPCC 2007)

Adaptation - *Practical steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change. For example, flood walls should be built and in numerous cases it is probably advisable to move human settlements out of flood plains and other low-lying areas…" (*http://unfccc.int/essential_background/feeling_the_heat/items/2911.php)

Adaptation - *Is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented*. (UNDP, 2005)

Adaptation - *The process or outcome of a process that leads to a reduction in harm or risk of harm or realisation of benefits associated with climate variability and climate change*. (UK Climate Impact Programme, Willows and Connell 2003).

Source: Levinia and Tirpak (2006).

Adaptation can be autonomous, where individuals and communities take action to reduce their own climatic risks but this is usually following implicit or explicit considerations of benefits they expect from making the change. For example, individuals may decide to construct stronger homes to better withstand a higher cyclone category, knowing that their families will be better protected.

Autonomous adaptation actions could also include the adoption of private insurance against future disaster events.

By comparison, governments may identify risks, implement planned initiatives for adaption to climate change and proactively invest in risk reduction. Government's actions are generally required when the benefits of specific activities will accrue to everyone and where individuals do not have incentives to meet the costs of doing so (IPCC 2007). That is, governments usually invest in activities that exhibit public good characteristics. With increasing vulnerability to current and projected climate change, and public good nature of many planned adaptation benefits, there is an increasing need for greater attention on planned and publically funded adaption to climate change risks (ISDR 2011).

Climate change adaptation exhibits key elements of disaster risk reduction (DRR) and disaster management (DM) (ISDR 2009; ISDR 2011). It comprises a range of policies, strategies and activities to reduce exposure to hazards and/ or vulnerabilities, to share and transfer risks, and to deliver dedicated responses to specific climate risks, across scales, times and across different levels of society (ISDR 2009; ISDR 2011).

Adaptation to climate change will involve specific actions to mitigate the losses associated with existing risk (compensatory risk management), measures that ensure that risk is not reconstructed after disaster events (reactive risk management), and measures that ensure that future development reduces rather than increases risk (anticipatory risk management). In addition, adaptation measures would reflect both potential impacts on socio-economic and environmental systems (seeUNDP 2002).

Adaptation decision-making process should include a systematic consideration of climate risk across national and sectoral planning and programming stages and when designing and implementing practical risk reduction and management activities (OECD 2009). Adaptation policies may either be directly incorporated into national goals or they may be drawn from the overall national development goals with changing climate in mind (Levenia and Tirpak 2006).

In the context of national development goal, this may include, climate change adaptation policy objectives about improved efficiency in water use and consumption(water sector), conservation of mangrove wetlands (forestry), enhanced food security (agriculture), improved public health (health and sanitation sector),or about improved livelihoods and human well being (cross sectoral), etc. At the sector level, they may include strategies and actions that operationalise national policies that maximize positive and minimise negative outcomes for communities and societies in climate-sensitive sectors; climate sensitive sectors as discussed above include agriculture, food security, water resources, health, coastal infrastructure. On the other hand, planned on-the-ground practical adaptation projects promoted by governments would operationalise those sectoral development and management objectives into actions that integrate or reflect climatic risks. Examples of on the ground activities include, planting of mangroves to rehabilitate degraded coastline as a storm buffer, water harvest and storage at the household level, or producing salt tolerant crops to cope with salinisation of coastal farming areas due to storm surges.

In many instances such adaptation measures would also make sense from a development perspective, whatever the future climate (Hellmuth, Moorhead et al. 2007). Where adaptation response focuses on conserving and protecting natural ecosystems, adaptation activities may include protection of coastal wetlands or catchment management. Such an approach is often referred to as ‘no regrets’ strategy as it provides benefits ‘triple-wins’ – providing cost effective risk reduction, support biodiversity conservation and enable improvements in economic livelihoods and human well being, particularly to the poor and vulnerable.

The term “*climate compatible development*” is often used when the focus is on reducing climate impacts through development efforts that also target low carbon initiatives (Mitchell and Maxwell 2010). Alternatively, planned adaptation strategy may also be aimed at building individual and institutional capacity, such as in the form of early warning system, to plan for, respond to, and cost effectively recover. At the individual and or private sector level, adaptation measures may include specific individual interventions or packages of related actions that they can adopt to reduce and manage their own risks, including risk transfer and sharing measures, such as disaster insurances which can help people have access to resources in times of disaster.

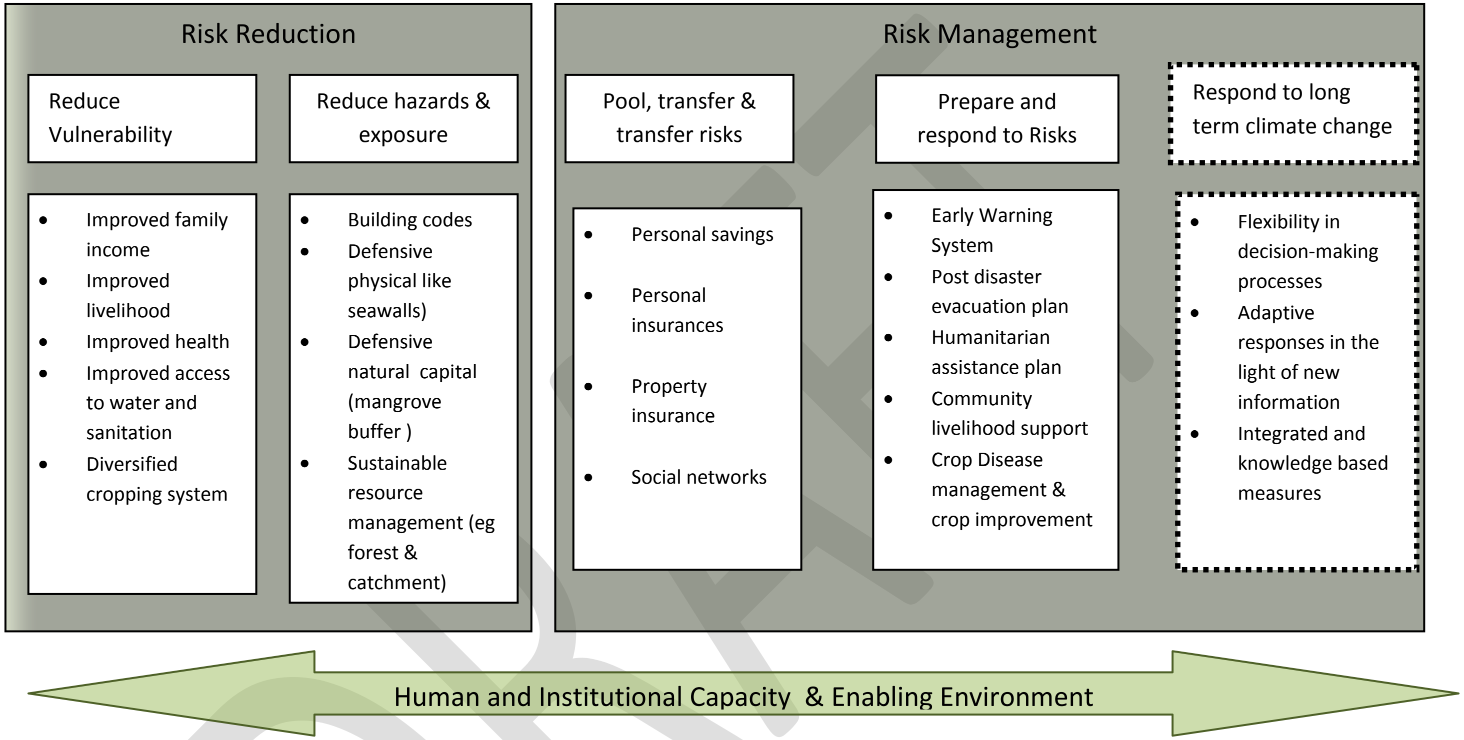
Proactive and reactive adaptation measures could therefore range from ‘pure’ development activities at the one end of spectrum to specific response measures at the other (McGray, Hammill et al. 2007; ISDR 2009; ISDR 2011). The spectrum of adaptation measures are summarised in Figure 3.1 include those that target:

- Addressing the drivers of vulnerability
- Reducing hazards and exposure
- pooling, transferring and sharing risks
- preparing for & confronting and reactively adapting to climate change

Adaptation decision-making

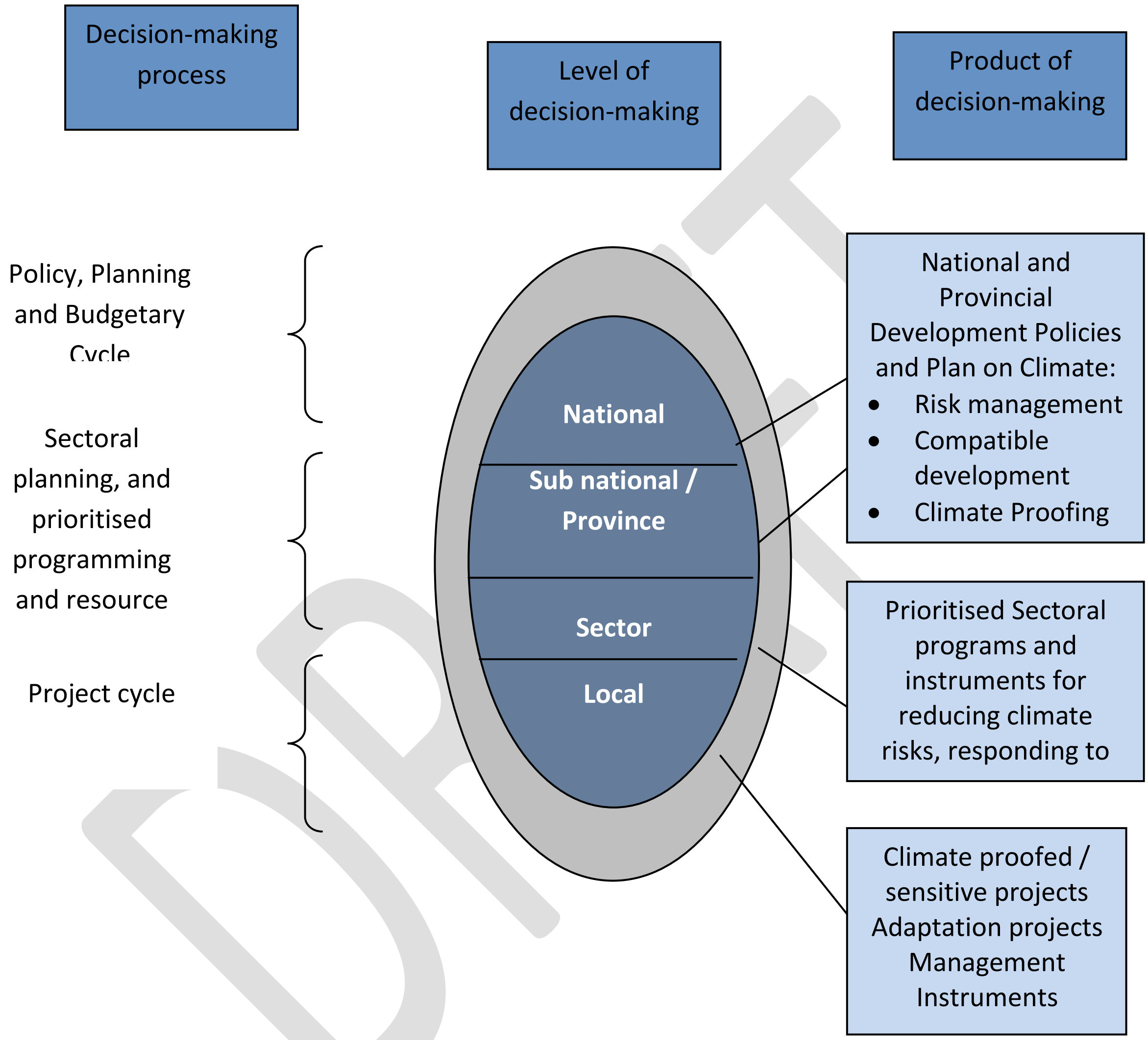
Decisions about adaptation to climate change are made across different levels of government and by different agencies, focussing on their respective functions and roles and generating different adaptation measures (Figure 3.2). Integration of climate change considerations at the policy level would thus follow the policy cycle process whereas at an individual activity level, project cycle-based iterative risk management is appropriate (Olhoff and Schaer 2010), (US National Academy of Sciences (Panel on Informing Effective Decision and Actions Related to Climate Change) 2010)); Willows and Connell (2003). Such a risk management cycle will essentially follow the stages of a policy/project cycle, with an explicit consideration of climate risks (Ollhoff and Schaer 2010).

Figure 3.1 Spectrum of Climate Change Adaptation Measures Mirrors Disaster Risk Reduction and Disaster Risk Management



Source: Based on McGray et al 2007.

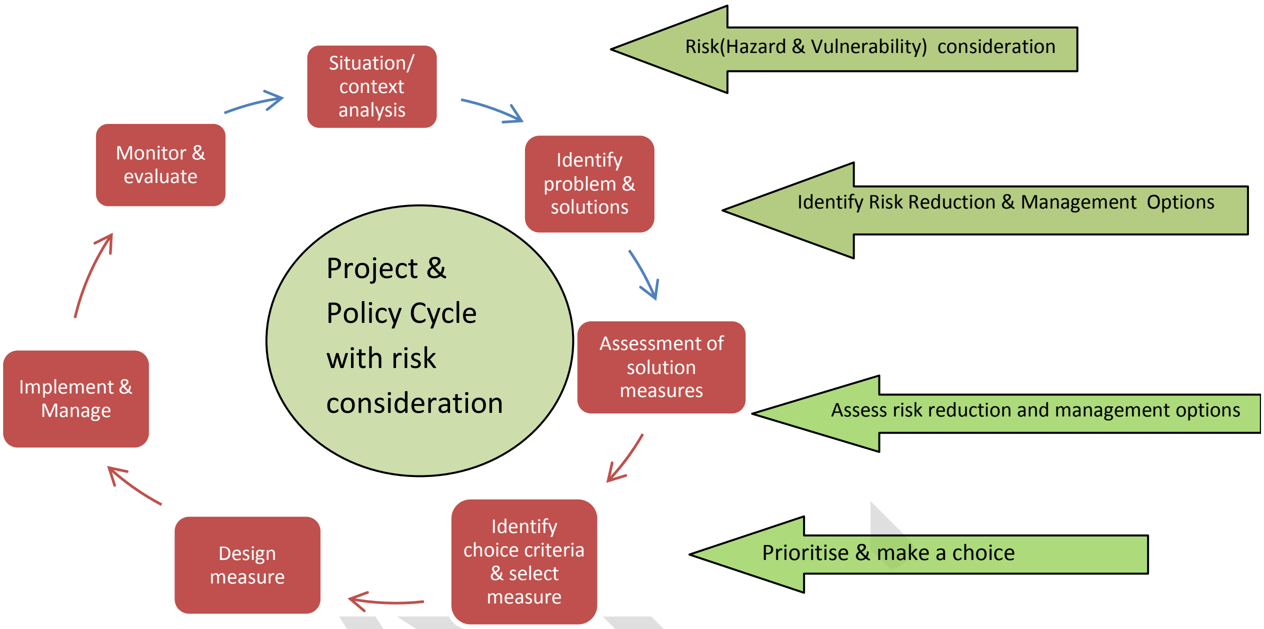
Figure 3.2 Targeting decision-making processes for mainstreaming of climate change risk considerations.



A policy/project cycle may follow the following key steps, some of which may be combined during implementation (Gittinger 1995, Lal and Holland 2009), integrating risk consideration at key stages (Willows and Connell 2003; Olhoff and Schaer 2010), as summarised in Figure 3.3:

- Situation or context analysis
- Analyse the issue/ problem, and identify solution measures
- Assess alternative measures based of an agreed decision-making criteria
- Choose an adaptation option and assess its feasibility
- Design the adaptation measure
- Implement and manage
- Monitor and evaluate
- Feedback adaptive loop

Figure 3.3 Risk Management Cycle relevant at the policy or project levels



Source: Adapted from Olhoff and Schaer (2010).

Applying a climate change lens during decision-making processes can enable decision-makers to identify potential hazards, vulnerable areas, local sectors, and people to target and develop climate proof measures and climate sensitive or climate compatible development measures, including policies, strategies, programs, on the ground' activities- and appropriate budgets.

In the context of climate change, the selection of policies and projects should be guided not only by their economic, social and environmental impacts, but also by risk reduction and management objectives. Other consideration may include technical and economic feasibility and the effectiveness of a measure in the light of uncertainties US National Research Council (Committee on America's Climate Choices (2011). Throughout such decision-making processes, assessment of social and economic costs and benefits of risks and climate adaptation measures is an integral consideration when making choices. This is regardless of the decision being made at the national and sectoral policy and planning stage or at the activity level and includes actions taken by private sector to manage their private climatic risks. Strategic environment assessment (SEA) and Environmental Impact Assessment (EIA) could help systematically identify individual measure's impacts during the government decision-making processes (King 2010 (draft)), although none of the PICs are currently using SEA process nor have enabling environment or resources to address this.

On the other hand, individual private sector, community or household level decision makers would normally choose between different adaptation options to invest in after comparing their benefits and costs of each option. Essentially they, too, would follow the project cycle-based risk management process illustrated in Figure 3.3.

Decision-making and economic assessment of climate change adaption

Economic cost-benefit analysis (CBA) is an established tool for determining the economic efficiency of development activity, particularly when there is pressure to achieve highest benefits with minimal investment. An adaption measure is considered to be efficient if the benefits outweigh the cost of that policy, program, or an activity, reflected in indicators such as net benefits (benefits minus costs), net present value, benefit-cost cost and or internal rate of return. CBA as a framework/ process can help decision-makers to systematically assess and compare different options, and choose the option that generates the highest economic efficiency. In the context of disaster risk management, the benefits of CCA are essentially the costs of damages, losses of disaster avoided (Mechler 2005; ECLAC 2003), and the costs are those associated with the particular adaptation measure.

From a technical perspective, to determine the value of avoided costs, or reduced damages and losses as a result of adaption measure, one would first need to estimate the risk. In technical terms, a risk is defined as the probability of potential impact of a hazardous event times the value of damages and losses (Mechler 2005). A loss frequency curve summarises the schedule of damages and its corresponding probability of an event not exceeding a certain level; conversely the probability of an event not exceeding a certain level is also often referred to as recurrence period.

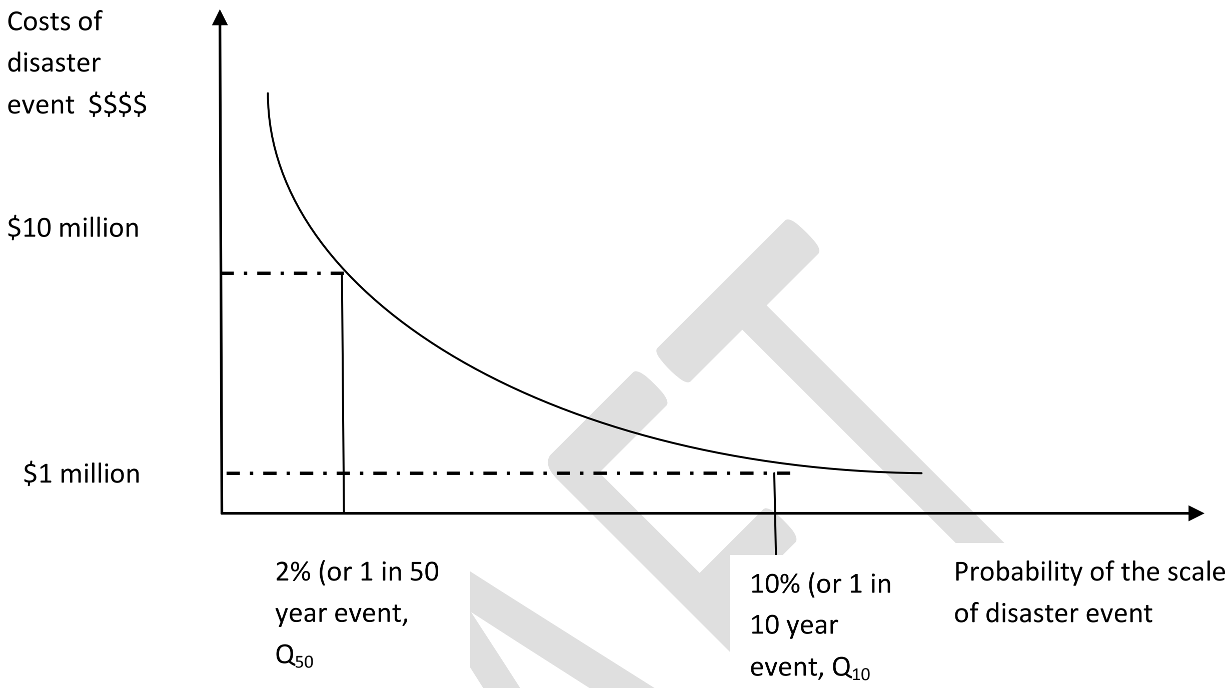
Thus, for example, if the current probability of cyclone of category 4 is say 10%; that is the category 4 cyclone induced flooding can be expected one in 10 years. If such a cyclone induced flooding causes $10 million in damages and losses, then the cyclone-induced flooding risk is estimated to be $1 million (=10%*10 million). Suppose through flood mitigation efforts, including better drainage of the flood plains, climate proofed infrastructure construction etc reduces the probability of flooding to 2% (or a recurrence of flooding of similar magnitude to say 50 years), the risk is reduced to 200,000 (=2% * 10 million). The benefit generated by the adaptation measure is then $800,000. Now suppose the flood mitigation effort cost $300,000, the net benefit of adaptation to the society is $500,000.

CBA of adaptation measure thus comprises two components:

- identification and assessment of climate related risks under projected climate change and variability ('without' adaptation) and the assessment of avoided risks through adaptation measures ('with' adaptation), and
- CBA analysis, comparing the net benefits of 'without' adaptation estimates of risks with that of the 'with' adaptation estimate of risk, netting the cost of the adaptation effort.

This approach has been widely used by the World Bank, the Asian Development Bank and the Inter-American Development Bank, as well as OECD countries to evaluate disaster risk management efforts, including in the context of development assistance (see e.g. (DFID 2005; Mechler 2005; Moench, Mechler et al. 2007; IFRC 2009; Venton, Venton et al. 2009; Vernon 2010).

Figure 3.4 Loss frequency curve and avoided disaster costs from adaptation

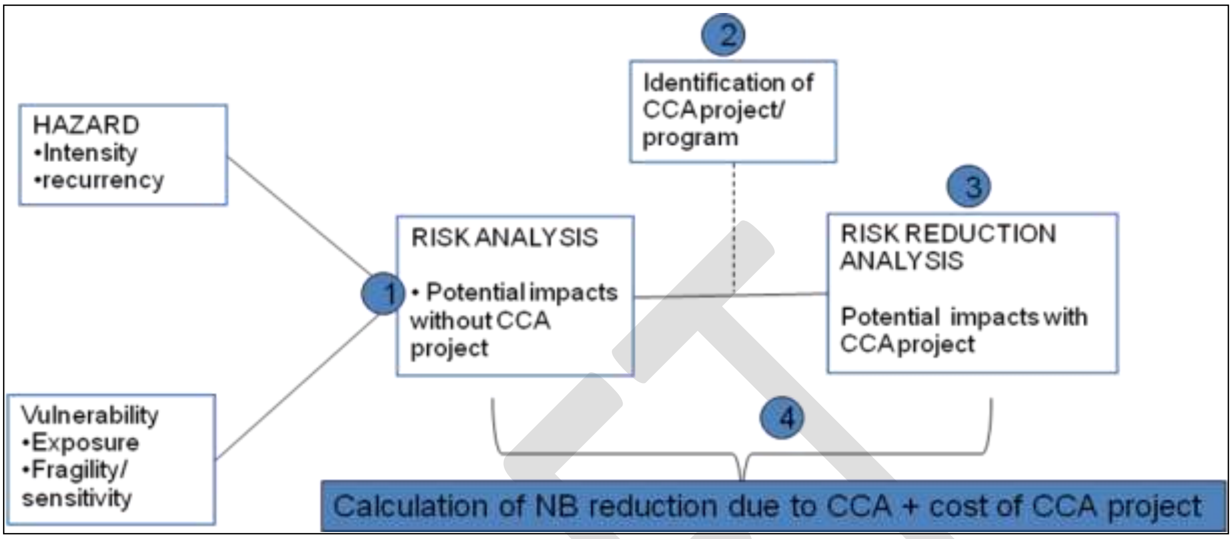


Practicalities of CBA of climate change adaption

For an empirical assessment of economic net benefits of climate change, ideally one would have robust results from climate modelling exercise, impact assessments and the assessment of expected reduction in risks from selected adaptation measures, as well as the respective associated social and economic information. For an economic cost benefit analysis under each climatic future, the following four technical elements are relevant, as illustrated in Figure 3.5 (Mechler 2005; Moench, Mechler et al. 2007; Mechler and The Risk to Resilience Study Team 2008):

1. Risk analysis – analysis of risks of potential impacts of climate change without risk management, and involves determining hazards exposure and vulnerability;
2. Identification of management/ adaption measures and associated costs, based on potential adaption activities and alternatives and their respective costs;
3. Analysis of risk reduction – i.e. estimated benefits of reducing risks; and
4. Estimation of economic efficiency, assessed by comparing benefits and costs of 'without' adaptation activity and 'with' adaptation activity; economic efficiency is the criteria of comparison.

Figure 3.5 CBA of climate change adaptation measures using 'with and 'without' risk assessment



Source: Mechler (2005).

Risk analysis

Risk analysis comprises three key components: hazard analysis, vulnerability assessment and climate risk analysis. Under each climatic future, hazard analysis would involve determining the nature and intensity of hazards that a particular area and community may be exposed to. BOM and CSIRO modelling exercise discussed in Chapter 2 shows there is still a large degree of uncertainty in determining projected climate futures for the Pacific islands. It is also difficult to empirically identify impacts on the different sectors, which as seen in Section 2, will depend on the changes in the specific climatic conditions that will be experienced in that country and locality. Nonetheless, one can assess current disaster effects and make some educated projections about the future events using the best scientific information available.

A disaster affects assets as well as flow of income or benefits (ECLAC 2003). From an economic perspective, effects of a specific climatic condition (i.e. damages and losses sustained) vary between direct or indirect, and monetary in nature and non-monetary. The types of direct and indirect damage and loss are summarised in Table 3. 1).

Table 3.1: Damage and loss and direct and indirect impacts from a disaster event

Category of impacts		Example
Direct	As a result of direct contact with the hazard, usually immediate effect on assets or stocks as well as flow of goods and services	Damage to houses, roads due to flooding following cyclone; Loss in value of crops damaged during flooding

Indirect	Occurs as a result of the flow on effect of direct impact	Increased waterborne diseases following flooding Loss in wages because business were closed during cyclone
Monetary	Impacts that have market value, and measured in terms of monetary value	Cost of building material required to repair the flood damage; or the cost of medicine required to treat water borne disease
Non-monetary	Impacts for which there are no direct market values	Cost of human suffering; the value of human life

To understand the nature of impacts that could be expected, vulnerability assessments could be useful. Climate change risks are, as mentioned above, determined not only by the nature of the hazard, but also by the society's vulnerability. Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR 2009). International literature (see e.g., Benson and Clay 2004; Benson and Twigg 2004) suggests that factors that drive vulnerability of local communities are linked to the structure and the status of the national economy, the condition of physical infrastructure (including access to water and sanitation) and the socioeconomic characteristics of households (including income, health and education). Vulnerability is thus the concept that explains why, with a given level of physical exposure, people are more or less at risk.

Vulnerability has three components necessitating vulnerability assessments to be carried out at different levels of decisions making to inform appropriate scale and scope of response - national, community or household level:

- the sensitivity of households, communities, economies and environment to hazards;
- their ability to respond to extreme events; and
- the ability to cope with the immediate effects of an event.

'Sensitivity' is used in this report to emphasise individuals' and communities' conditions that particularly have the potential to magnify the effect of disaster.

At the national level generally, vulnerability is high in many areas as a result of poor infrastructure, which is often perceived as a key component of a country's economic status. Freeman (1999) demonstrated a direct link between vulnerability to natural disasters and poor infrastructure. Poor infrastructure affects people's ability to engage in income generating activities as well as their ability to respond to disasters. Poor infrastructure standards, weak government regulations (such as the absence of building codes) and weak regulatory enforcement also increase disaster risks.

Countries that heavily rely on the primary sector are also generally found to be more sensitive to the effects of natural disasters (Benson 1997; Benson and Clay 2004), particularly disasters of hydro-meteorological origin. At the same time, the process of development adopted and the development choices made in many countries affect those countries' vulnerability to disasters—for example, environmentally unsustainable development practices, such logging in areas prone to landslides and increase disaster risks. Human vulnerability is exacerbated by weak end-to-end disaster warning systems and the ability of people to manage disaster.

At the household level, the sensitivity to external shocks can be assessed in terms of their economic well being, food and nutritional status, as well as access to water and sanitation. These are part of the human development index adopted globally, which at the national level reflects conditions such as household income, access to water and sanitation, maternal and child mortality, and education (UNDP 2010). The poorer the economic and social wellbeing at the household level, the more sensitive the household is to the impact of hazards (primarily because it has a low threshold for withstanding external shocks). They are also less able it is to respond to, cope with and adapt to disasters because they would not have much, if any, financial and social capital on which to draw on (IISD, IUCN et al. 2003; Elasha, Elhassan et al. 2005).

Vulnerability assessment would thus involve understanding context-specific needs and aspirations of people, and sensitivity of their livelihoods to hazards, including their asset base, lifestyle, economic activities and wellbeing. Such an assessment can be approached using the sustainable livelihood framework, which can help assess people's sensitivity to hazards of a specific intensity and scale, understand the local level risks, risk management and resilience at the household and community level, as well as used as a practical tool for designing programs and evaluation strategies aimed at improving livelihoods (IISD, IUCN et al. 2003; Elasha, Elhassan et al. 2005).

Such information will then be used to determine the current situation and projected changes in the economic and social conditions, considering also the other underlying drivers of human conditions. Such analysis will thus be very context-specific. Combined information on the likelihood of hazard, community's exposure to it and vulnerability to a hazard event then enable the quantification of risks (probability of the event and it potential impacts). In the Pacific, although some vulnerability and adaptation (V&A) assessments have been done as part of adaptation projects in the Pacific, empirical estimates of risks have though generally not been attempted (see below).

Identification of risk management measures and risk reduction analysis

A holistic system view of risks and risk management is required to identify relevant risk management measures, recognising the multidimensional nature of the effect of climate change, the presence of a diverse set of stakeholders, playing complementary roles, across all levels of government, sectors and scales, as well as the community and private sector. As highlighted above, such adaptation measures would address a spectrum of risk reduction initiatives (Figure 3.1) and include policies, strategies, programs and portfolio of projects as well as individual activities (Figure 3.2) (Willows and Connell 2003; Olhoff and Schaer 2010; Ranger, Milner et al. 2010). Such an analysis will ideally draw on many different disciplines, and traditional knowledge, and would involve backward assessment to inform the forward looking responses, or forward looking assessments based on scientific modelling.

Two alternative adaptation planning approaches are generally advocated for responding to climate change: 'science or impact first' and 'vulnerability first' assessments (Dessai, Lu et al. 2005; Ranger, Milner et al. 2010), informed by a combination of scientific and local knowledge acknowledging dynamic nature of risk and uncertainties in future climatic scenarios (IPCC 2007).

The ‘impact first’ approach involves identifying climate change scenarios using scientific climate models, assessing impacts based on projected climate change scenarios derived from the modelling exercises, identifying, assessing and selecting relevant adaptation measures, recognising underlying uncertainties, implementing the adaptation measure and then assessing the outcomes, and learning (Figure 3.7). On the other hand, the ‘vulnerability first’ approach starts by examining current vulnerability and sensitivity conditions that the communities currently face, identifying local sensitivities and resilience of the natural and human systems to climatic hazards, identifying local priorities to climatic variability and then identifying viable adaptation strategies and actions required to improve their resilience and the considerations of projected climate conditions are also considered at this stge.

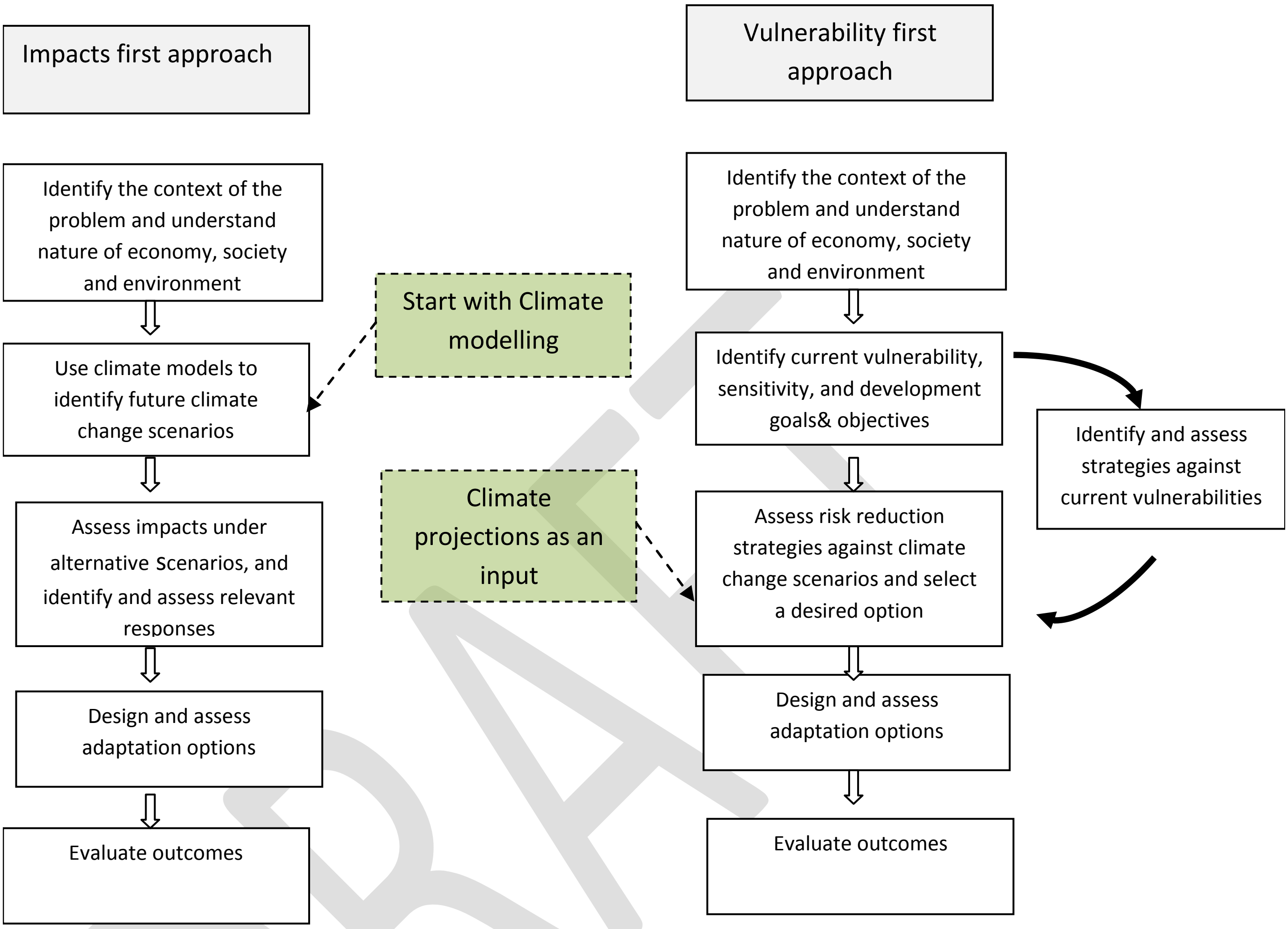
The vulnerability first approach also includes the adaptation policy framework, which pre-supposes that adaptation to short-term climate variability and extreme events will reduce vulnerability to longer-term climate change; adaptation policies and measures are assessed in a development context, with some reference to future climatic conditions and for which the adaptation strategy is equally important as the process by which it is implemented (UNDP 2004). The difference between the two is the stage at which climate change scenario is considered- in the impact first approach, the starting point is projected climate change scenarios; where as in the vulnerability first approach, climate change scenario is considered after current drivers of vulnerability are assessed and responses identified (Figure 3.6).

Best’ CCA option – Economic and ‘Economic Plus’-Based Criteria

An economically optimal adaptation measure is one which is most efficient, that is one that generates the greatest benefits after the costs of implementing it have been considered. If the probability of events and impacts can be quantitatively determined, as mentioned above, the ‘expected losses without adaptation can be estimated using loss frequency curves (Mechler 2008) (see Figure 3.4). The benefits of adaptation can then be determined comparing economic values associated ‘with and without’ the option. If the benefits of an initiative are expected to occur over extended periods of time, the appropriate measure of comparison is then the present value of costs and benefits, discounted using rate of time preference of the community for the present over the future.

International literature suggests that if detailed probability of events and impacts are not known, then sensitivity analysis is relevant to reveal possible tradeoffs that may be necessary, using various criteria such as “maximin”, where the best outcome of the most pessimistic scenario is selected; this may also include a situation where an adaptation scenario which is considered to be unacceptable for political reason being rejected (Hallgate et al 2011).

Figure 3.6 Impacts-first approach (Left) and Bottom-up vulnerability first approach to adaptation planning (Right)



Source: Adapted from Willows and Connell (2003); UNDP (2004); Ranger et al (2010).

There are several challenges in identifying the 'best' adaptation measure on the basis of economic efficiency. Firstly, the principle generally assumes that all benefits and costs of risk reduction are identifiable, quantifiable and quantified in monetary terms. In reality, this may not always be possible. Detailed quantification of the benefits of some adaptation measures, such as policies, and plans, in a lot of cases may not always be feasible - this is especially true in the Pacific - because:

- baseline data is frequently limited;
- there may be a high degree of uncertainty concerning future scenarios; and
- climatic risks and potential impacts of climate change, variability and extremes can be difficult to determine in the absence of relevant scientific knowledge.

Furthermore, instead of individual adaptation measures, which can be subject to CBA, in most cases a portfolio of interventions may be required within a complex development context. In such a situation, the broader functioning of the national economy, transport, communication, educational and other systems, may have more fundamental implications for exposure, vulnerability and risk than individual, or multiple, hazard-focused interventions (Moench, Mechler et al. 2007). In such circumstances, the geographic scale of the sphere of influence of possible adaptation measures is often large, and benefits may accrue across hard-to-identify groups of people, and CBA as an assessment tool may not be totally appropriate for making a choice. This may also be the case when benefits and costs accrue sometime in the future and there is no agreement over the relevant discount rate to use (Moench et al 2007; Moench and Dixit 2004 (quoted in Moench, Mechler et al. 2007)).

Additionally, economic efficiency-based decisions do not typically reflect consideration of who bears the cost of a measure and who enjoys its benefits. Further analysis could help differentiate between the groups of society that may be most affected and assessment of the spatial distribution of hazards, the vulnerability of the local communities and the potential impact of the adaptation measure would also need to be understood, and equity and other social criteria would be required when making choices.

Despite such limitations, CBA is still considered to be a useful framework to support decision making. It provides a framework and a process to decision-makers to systematically identify, evaluate and consider all, qualitative, and or quantitative, costs and benefits of an initiative. While CBA application may not always result in an exact economic value, it can help guide to an expression of society's preferences (Mechler 2005; Moench, Mechler et al. 2007).

Where there is a mixture of quantitative and qualitative information available about costs and benefits of adaptation options, multi-criteria analysis (MCA), or deliberative MCA could be used to determine a preferred CCA option involving multi stakeholder groups representing diverse interests in the community (Mendoza, Macoun et al. 1999).

In the absence of even basic scientific information, a more pragmatic approach to the selection of adaptation measures is suggested, using strategies that are considered to be 'no regrets', which addresses current adaptation gap and decreases people's vulnerability to current hazards. As discussed earlier, 'no regrets' measures make sense from a development perspective, whatever the future climate (Hellmuth, Moorhead et al. 2007), and can be applied across all levels of decision-making and at all scales. Such 'no regrets' strategies may include the adoption of sustainable livelihoods-based development projects that target poverty reduction, building human skills and capacity to make informed decisions. They could include sustainable resource management and ecosystem based adaptation, and conservation of environmental services (Carney 1998; IISD, IUCN et al. 2003; Elasha, Elhassan et al. 2005). Ecosystem based adaptation could produce 'triple-wins' – providing cost effective risk reduction, support biodiversity conservation and enable improvements in economic livelihoods and human well being, particularly to the poor and vulnerable.

The three-tiered social and economic assessment

Acknowledging that quantitative social and economic assessment of adaptation measures is not always possible due to data and capacity constraints, Ranger and others advocates a pragmatic three-tiered assessment approach to assessing CCA from a social and economic perspective (Ranger, Milner et al. 2010)

- qualitative risk screening;

- qualitative or generic quantitative risk assessment; and
- quantitative risk assessment.

The level of analysis undertaken may depend on the availability of information and the stage at which such assessment is being carried (Table 3.2); social and economic assessments as discussed above in Chapter 3 are usually carried out during stages 1-4 of the project/ policy cycle (Figure 3.3).

Table 3.2: Pragmatic three tiered social and economic assessment approaches to underpin key decisions

Tier 1	Qualitative Risk Screening	A broad-based risk assessment used to identify the impacts of important drivers of risks, and which also may help to identify broad adaption options
Tier 2	Qualitative or generic quantitative risk assessment	Qualitative or generic and aggregate level quantitative risk assessments that help characterise risks in more detail and prioritise them. This provide a more detailed picture of risks and their dependencies, the level of confidence in projections and the sensitivities decisions to different scenarios and uncertainties. Qualitative judgement based assessment would suffice. While this assessment may be more detailed that in tier 1, it may not involve detailed empirical assessments and calculations.
Tier 3	Specific quantitative risk assessment	Quantitative values of the benefits of different options are estimated given the uncertainty. This step is usually undertaken when data exists and climate projections and impacts are known with a degree of confidence, and or quantitative assessment combined with sensitivity analysis provides a better set of information to make choices.

The approach also emphasises a phased analysis, where decision-makers move from broad to detailed analysis depending on the level of decision (policy, programme or project); the level of understanding there is about how climate change will affect the decision-making and the whether or not the decision is directly in response to climate risk, or indirectly in response to an activity that is influenced by climate (Willows and Connell 2003). Such a tiered approach may be highly applicable to the Pacific context, where some hybrid three-phased assessments may be undertaken and decisions made on the basis of qualitative and quantitative assessments and expert and stakeholder judgements.

For the Pacific, choice of adaptation measures are most likely to be also guided by criteria such as considerations of existing development challenges, current disaster risk, and or projected level of climate change and associated uncertainties. In order of priority, this may include:

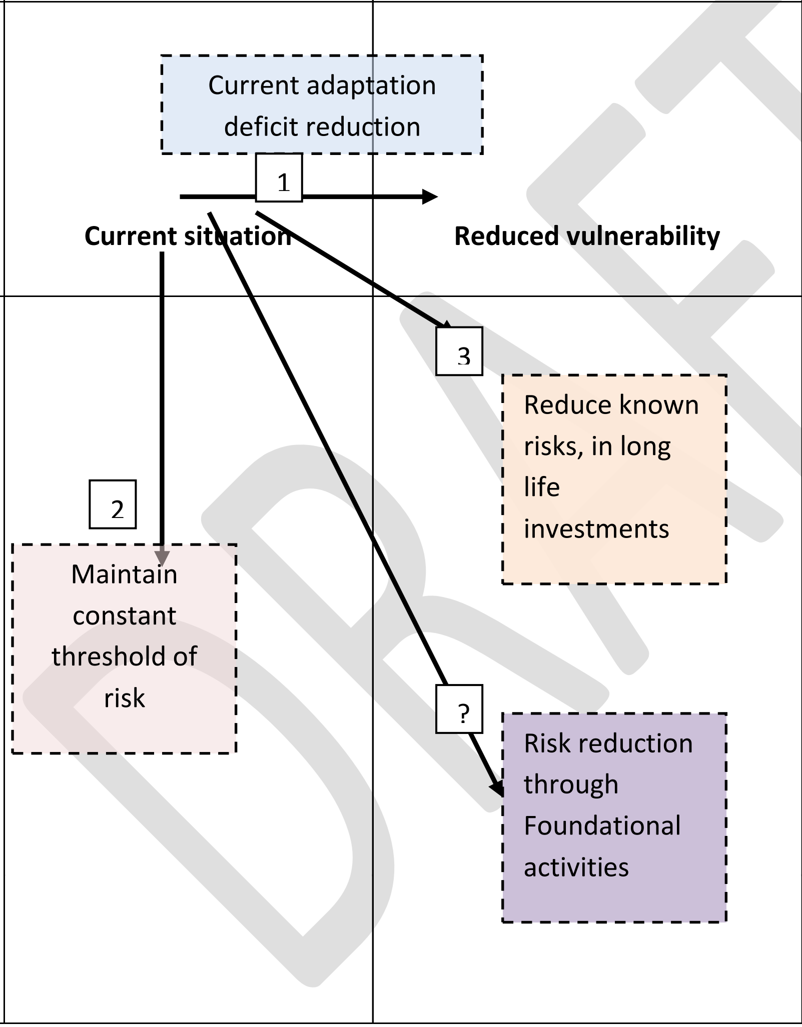
1. reducing impacts currently being experienced due to weather and climatic conditions, including El Nino and La Nina based variability in sea level, and rainfall, storm surges, and extreme weather events;
2. reducing impacts that are expected to occur in the near future due to climate change rainfall, sea level rise storm surges, and extreme weather events; and
3. projected impacts that are supported by well established science and are likely to occur in the distant future, and for which adaptation strategies are designed to have effect in the long-term (e.g. Limited rise (< 1 meter)in sea level), or impacts that may be experienced in the distant future and are uncertain, but with potentially serious consequences, such as major rise (>1 meter) in sea level.

Countries may also wish to also prioritise initiatives that would help create an enabling environment and lay a solid foundation to improve the effectiveness of future decisions. Such foundational measures could include baseline database, institutions and human capacity to make more informed decisions.

Figure 3.7 gives a few practical Pacific examples of the kinds of adaptation projects that may be considered priority 1, 2 or 3.

Figure 3.7 Prioritisation of Adaptation Measures

Figure 3.7 Prioritisation based on Urgency, longevity and foundational requirements and activity examples from the



	Current risk level	Preferred/ Desired risk level	*Examples of Adaptation Measures*
No climate change			1: Addressing current deficit • *Water harvesting and storage in Tuvalu* • *Storm protection through Replanting of Mangroves* • *Leaf blight resistant crop improvement in Samoa* • *Relocation of Lateu village, Vanuatu*
With climate change			2: Constant level of risk despite changed conditions • *Climate sensitive crop improvement in Vanuatu* 3. Known Increased risks and long life investments • *Climate proofed road infrastructure in Solomon Islands,* • *Revision of standards for Drains and Drainage networks in Fiji (PACC)* 4: **Foundational activities** • institutions & Baseline information system, • *Ex situ and in situ germplasm conservation and regional institutional partnerships* • *GIS-based Baseline Hazard, vulnerability information*

Source: Based on (Hallegatte et al. 2011)

Part 2: Pacific challenges in economic and social assessment based climate change adaptation decision and the way forward

Pacific island countries have implemented many different types of projects and programs. To illustrate the nature of challenges faced in the use of economic and social assessments to inform climate change adaptation decisions, two types of assessments are provided. Using the broad policy/ project cycle process and CBA analytical framework a detailed analysis of case studies of four recent adaptation projects (Section 4) and a review of key economic assessment efforts at the project and national/ sectoral planning levels are found in Section 5.

Chapter 6 then draws on Chapters 3, 4 and 5 to identify practical steps towards strengthening economic and social knowledge based climate change adaptation choices.

4. Economic and Social Assessment of CCA Projects in the Pacific: Illustrative case studies

Illustrative case studies were selected to cover four priority sectors of concern in the Pacific countries including; water, agriculture (food security), infrastructure and coastal (relocation) These case studies were also selected to investigate adaptation activities in an atoll (Tuvalu) and in high island countries such as Vanuatu and Solomon Islands and Samoa. An adaptation project that was already completed (Latea village relocation) was also investigated and several projects in progress. These projects also covered adaptation needs that might occur in relation to the effects of projected climate change in precipitation (drought and flooding), temperature (humidity) and minimum night time temperature ; sea level rise and storm surges (Table 4.1). The following four climate change adaption initiatives were selected for detailed cost benefit analysis (CBA) to identify in more detail the nature of issues and constraints faced in undertaking economic and social assessments of CCA activities.

Table 4.1: Case studies selected for detailed country level assessment

Climate Change Adaptation Issue **Title of case study**	**Climatic Parameters**	***Island characteristic/ Island***	**Status of project**
Food security and climate resistant crops Assessing the social and economic value of germplasm and crop improvement as a climate change strategy: Samoa and Vanuatu Case studies	*Precipitation (humidity) and minimum night time temperature*	*High Island* *Samoa* *Vanuatu*	*Samoa – the initial phase primarily completed (2010), although crop improvements ongoing* *Vanuatu – primarily completed in 2008 although crop improvements ongoing*
Water security Water quality, quantity and sanitation improvements as an adaptation to climate change, Tuvalu	*Precipitation (drought and flooding)*	*Atoll island* *Tuvalu*	*Ongoing*
Climate proofing of infrastructure projects Climate proofing of road improvements in North-western Guadalcanal, Solomon Islands	*Precipitation (river flooding)*	*High Island* *Solomon Islands*	*Due to complete in 2012*
Coastal: relocation/ resettlement/ migration	*Sea level rise and storm surges*	*Coastal*	*Completed in 2005*

Social and economic assessment-based climate risk management: A case study of sea-level rise and relocation of Lateu community, Vanuatu		*Vanuatu*	

The food security and crop improvement case study involves a number of discrete sets of activities (rather than a discrete project) supported by several different development partners and implemented over time, all leading to improved crop varieties introduced in Samoa and Vanuatu. By comparison the water security case study considers three separate projects, running in parallel all addressing similar national priority issues with possibly limited coordination. The climate proofing of road improvement in the Solomon Islands is an example of a project with long investment life funded under a loan from a Financial Institute (ADB), with clear climate proofing policies, and implemented by a large consulting company with extensive experience in infrastructure projects. The coastal relocation project in Vanuatu has been identified as the first climate adaptation project to be implemented in the Pacific. Another key feature of all these case studies, except the ADB Solomon Islands project is the use of limited empirical baseline information, or information generated during the project. The ADB project, while using some detailed technical / engineering information also suffered from key analytical issues.

The case study assessments represent mainly a semi exante/ ex-post evaluation of the CCA projects, with the exception of Vanuatu root crop germplasm project. The assessments discussed below adopted a combined project cycle-based risk management framework, and economic assessment of the CCA activity was framed using a probabilistic CBA tool (Mechler 2005). The risk management cycle based decision-making, as discussed in Chapter 3, involved:

- risk analysis - determining hazards exposure and vulnerability without adaptation project
- identification of suitable management/ adaption measures and associated costs
- analysis of risk reduction from CCA activity– i.e. estimate benefits of reducing risks
- estimation of economic efficiency, assessed by comparing benefits and costs using an agreed economic efficiency criteria

In all the CCA projects discussed in this report, information about climate change scenarios was sourced from IPCC AR4 report, other results of global models and or key climate parameter information accessible by the project proponents. Although CSIRO has recently produced climate change scenarios for the Pacific island region under the Pacific Climate Change Science Program of the Australian Government, this data could not be used to undertake the risks analysis as much of the climate change projections data is in a form that would need to be translated into key hazards (droughts, floods, conditions suitable for crop disease outbreaks, etc) before attempting to identify loss frequency functions. It was beyond the scope of this small DCCEE-IUCN project to revisit those hazard and vulnerability analysis to identify loss frequency functions, particularly as this would have required other sectoral specialists undertaking detailed assessment of the changes in climate change and the impacts on respective sectors. This highlights the first key constraint in doing probabilistic (or for that even deterministic) CBA of adaptation initiatives– the presence of poor baseline scientific understanding about the hazards, risks and vulnerability to undertake risks analysis and estimate potential impacts without application of risk management strategies. All the CBAs reported here though could only undertake deterministic CBA due to data limitations. Sensitivity analysis around key parameters was conducted where appropriate.

These case studies also highlight key issues and challenges regarding processes used to identify specific adaptation responses and selection of adaptation options, programmatic or individual activity based approaches, project design, and the use of available scientific and traditional knowledge, as well as the level of stakeholder involvement. The case studies discussed here examine the following for each CCA projects investigated including:

- The nature of risk analysis undertaken;
- Approach used to identify management/ adaption measures, select adaptation response and associated costs;
- The nature of risk reduction analysis was undertaken before implementation – i.e. estimated benefits of reducing risks; and
- Semi exante-expost estimation of economic efficiency measures.

Key issues and challenges experienced in the implementation of specific climate change adaptation initiatives in the region summarised below draw on the detailed case study reports included in the compendium volume. These reports were prepared by teams of researchers under the leadership and guidance of IUCN:

Case Study	Title	Authors
1. Food security	Assessing the social and economic value of germplasm and crop improvement as a climate change adaptation strategy: Samoan and Vanuatu cases studies	Andrew McGregor with Peter Kaoh, Laisene T. Marina, Padma N. Lal, Mary Taylor
2. Water security	Water quality, quantity and sanitation improvement as an adaptation to climate change, Tuvalu	Federica Gerber
3. Relocation	Social and economic assessment-base climate risk management: a case study of sea level rise and relocation of Lateu community, Vanuatu	Padma N. Lal, Wendy Proctor, and Kim Alexander
4. Infrastructure climate proofing	Climate proofing of road improvement in North-western Guadalcanal, Solomon Islands	Valentine Thuirarajah and Padma N. Lal

For detailed analysis and key documents consulted and literature used, please see respective case studies attached.

Case Study 1: Food security

Pacific island countries rely on their agriculture sector for much of their food and nutritional requirements, as well as income. It is a sector that relies primarily on rain-fed small-holder commercial production systems. As such the people and their economic activities are highly vulnerable to trends and variability in weather and climatic conditions. Coastal areas are also vulnerable to sea level rise due to climate change and usual variations due to ENSO events and storm surges, causing salinisation of the farming areas.

The effects of climate change are already being experienced, with decreases in crop yields, changes in flowering and crop suitability over different altitudes, as well as outbreaks of pests and diseases due to changes in temperature and humidity conditions. Such effects are expected to be exacerbated with projected changes in climate variability and extreme weather events, sea level rise and increased storm surges. In the face of climate change and a high level of climatic variability, a range of agricultural sector related climate sensitive and climate ready adaption strategies and coping mechanisms have been recognised for implementation, including:

1. Enhancing the resilience of traditional and sustainable cropping systems;
2. Promoting appropriate traditional planting material preservation;
3. Developing improved germplasm for crops that is better suited to climatic extremes and the associated pest and disease problems; and
4. Ensuring that secure and effective planting material production systems (community, national and regional) are in place. These systems need to be supported by efficient distribution systems (which ensure planting material is available immediately when required or are in advance of climate induced disease outbreaks taking place) coupled with knowing the climatic limits of the actual crops and varieties.

This case study discusses cost benefit assessment of germplasm conservation and crop improvement as a climate change adaptation strategy by focussing on three different approaches:

- reactive program of activities that addresses climate sensitive taro leaf blight disease outbreak in Samoa (See Figure 3.8: pathway #1 - addressing current risks)
- proactive program of activities that focuses on increasing genetic diversity of traditional crops in farmers fields in Vanuatu (See Figure 3.8: pathway #2– preparing for longer term changes)
- proactive program of activities that help lay a solid foundation for adaptive responses to uncertain variability and extreme events (Figure 3.8 pathway #4- Foundational activities)

Reactive response: Taro leaf blight resistant crop improvement

Traditional Pacific island crops are particularly vulnerable to disease due to their narrow genetic base. This makes root crops particularly susceptible to the impact of diseases brought about by the impact of climate change such as taro leaf blight (TLB).

TLB is a fungal disease which prefers high night time temperatures and relative humidity. The fungal disease significantly reduces the number of functional leaves, and can lead to yield reductions of over 50%. TLB was first detected in Samoa in 1993, when it rapidly spread across the two main islands, Upolu and Savai'i. Various factors contributed to the rapid spread of the disease in Samoa, including factors such as planting of the same variety of taro in large areas which effectively ensured a mono-cropping situation comprising a highly susceptible variety and the significant replanting effort of taro which took place in the aftermath of Cyclone Val, which also added to the movement of planting material between islands. The weather conditions at the time were conducive to rapid spread of the disease and quickly reaching epidemic proportions; strong winds and high relative humidity; high night time temperatures and high relative humidity are ideal conditions for the spread of the fungal spores.

Projected changes in climate across the region, including warmer conditions and a rise in minimum night time temperature and relative humidity, increase the likelihood of the TLB spreading to locations that are currently free of the disease. Areas that are now free of TLB, such as Fiji, Tonga, Vanuatu, the Cook Islands and higher elevation areas of PNG, are all susceptible and are all seen to be at high risk. TLB could become established and or more prevalent in such countries which are projected to have average warmer conditions combined with wetter to much wetter conditions (See Figure 2.1a above).

The Samoan case study demonstrates that a TLB epidemic represents a major disaster with large economic and social consequences.

TLB had a devastating impact on the Samoan taro production, with an annual loss in production valued at (Western) Samoan Tala (WST) 25 million (or AUD 11 million) between 1994-1999. For 5-6 years following the arrival of TLB, little taro was consumed in Samoa, a distinct difference from the 1989 census records which showed that almost 96 % of agricultural households grew and consumed taro. Combining these two together, Samoa suffered an annual loss in foregone domestic taro consumption valued at WST 11 million and a taro export valued at WST 9 million.

Management responses

The initial response to TLB consisted of standard agricultural farm management practices, including spraying of infected planting material with fungicides, which proved to be ineffective. Farmers were reluctant to incur the extra costs involved, even with the government subsidy towards the cost of the fungicide. Although there were also quarantine measures put in place to restrict the movement of planting material, which was also supported by awareness campaign, the TLB could not be contained, as the climatic conditions favoured rapid disease development.

After the traditional methods for the control of TLB did not provide positive results, attention focussed on the introduction of exotic varieties resistant to TLB (in particular from Asia and Palau) Although the introduction and use of these TLB resistant taro varieties enabled Samoan farmers once again to cultivate taro, there was general consensus that these varieties were not ideal because of the strong variance in taste. As such attention shifted towards a longer term breeding of taro, where the challenge was not only to find resistant varieties but also to meet the demanding taste requirements of Samoan communities at home and abroad, and to provide for a shelf life that would allow export by sea.

The challenge was met by using a classical plant breeding approach, which incorporated a high level of grower participation. The initial breeding program involved University of the South Pacific (USP) plant breeders and the Ministry of Agriculture staff utilising their own funds. Later external funds of about WST 18 million (AUD 8 million) were incrementally obtained between 1994-2010 from partners such as AusAID (TAROGEN project), ACIAR (DNA finger printing and virus testing protocol development projects), and NZ Ministry of Foreign Affairs (assessment of TLB resistance methodology), to support the breeding program that eventually led to the introduction of TLB resistant taro varieties in Samoa. AusAID also contributed towards the establishment of regional germplasm conservation at the Centre for Pacific Crops and Trees (CePaCT).

This breeding program was informed by scientific knowledge, including genetics and crop breeding techniques, and farmer experiential knowledge and farmer trials, as well as community preference trials in Samoa. The preferences of the Samoans living aboard were not initially tested. Farmer participation in the field trials ensured trials across many locations and quick uptake.

Expost estimation of economic net benefits of TLB resistant crop improvement as a CCA strategy

Even though TLB resistant crop breeding activities were developed incrementally over time, the cumulative result of the largely publically funded TLB resistant crop improvement program far outweighs the costs. Production of *Colocaisa* taro for the domestic market has increased from virtually zero to 9000 tonnes in 2010, with some 500 tonnes sold in the Fugalei Market. Local consumption is valued at WST 21 million (AUD 9.3 million) and the FOB value of exported taro is estimated to be WST 1.1 million (AUD 0.5 million).

The export value of actual taro crop outputs for export and domestic markets and subsistence consumption over the period 1994 through to 2010, is 10 times the cost of the breeding and germplasm conservation program; the latter was estimated as a prorated cost of the regional CePaCT germplasm conservation program. Sensitivity analysis, using a range of discount rates between 2% and 15%, provides a BCR ranging from 10.7 to 12.5.

Taking into account expected growth in the domestic consumption, considering recent trends in the consumption of rice and wheat, the value of taro at the Fugalei market is projected to be about WST 25 million (AUD 11 million) by 2030. With the projected increase in the markets, and continued breeding and extension program at nominal costs, the projected BCR is 16.4 for a zero discount rate to 15.1% at 15% discount rate.

The success of the Samoan taro breeding program can be attributed to:

- A major crisis that made it possible to focus the minds of government decision makers and donor agencies to eventually secure the necessary coordinated and sustained response of the funding and implementing agencies. Eliciting an ex-ante response of equivalent scale is much more difficult task – although this is what is now required for other countries and for other traditional crops;

- The high calibre of the key people involved in the identification of project and it subsequent implementation. In particular the USP taro breeder has from the outset been critical to the success of the program'

- The direct involvement of farmers in the taro breeding program; and

- The existence of regional germplasm banks at SPC and USP. Importantly, the success of the taro breeding program was made possible because of the access to diversity through the Pacific region's genebank, in particular, the south-east Asian taro from the TANSAO project which provided the much needed diversity to progress the breeding program to the stage it is at today. For Samoa to have imported this material directly would have been very difficult, especially taking into account the need for virus testing.

The Samoan program took several years to get started – which meant there were substantial costs in terms of lost benefits.

Although the net benefits of the TLB crop breeding program show significant value, the economic and social benefits could have been much greater if Samoa or the regional germplasm banks had contained key taro genetic material from the region as well as Asia. To address Samoa's TLB disease outbreak, several years were spent getting a cohesive crop improvement program based on genetic material sourced initially from Palau and later from Federated States of Micronesia, the Philippines, and other south-east Asian genetic material maintained in CePaCT. Such delays and costs to local communities and loss in the export markets could have been avoided had investment in regional ex situ germplasm banks been made much earlier.

An important lesson learnt for other countries is the need to be able to respond quickly to the arrival of diseases such as TLB (as well as changes in the range in climatic conditions and extreme). For this, easy and prompt access to diversity, through strengthened planting material distribution system involving national and regional germplasm banks is essential. However, a complete reliance on regional and national germplasm banks is not an ideal risk management strategy, as ex situ germplasm banks, especially filed collections, have been known to lose key collections due to diseases, financial unrest and other types of accidents (Caillon et al 2004). A proactive response is required, with the germplasm in-country and, ideally, in the hands of the farmers prior to the arrival of the disease. The Vanuatu program is an example of how this can be done.

Investing in foundational institutional capacity

Due to the severe consequences of the TLB disaster it was possible to eventually focus the attention and support of national government agencies (primarily the Samoan Ministry of Agriculture), regional bodies (SPC and USP), and development partners (AusAID, NZ AID and ACIAR). To avert similar disasters occurring in other PICs, proactive action is required by these countries for other traditional crops, especially in light o the expected challenges to climate change. Without this proactive approach, the ability of and the time it will take for the countries to recover from these challenges is likely to be severely impacted.

An example of such a proactive step in the region is the Vanuatu germplasm distribution program which is analyzed in the second case study.

Proactive response: strengthening flexible and sustainable capacity in Vanuatu

The Vanuatu approach, in contrast to that described for Samoa, relies on evaluating local diversity, incorporating some exotic diversity, and then distributing large volumes of planting material for farmers to select from, and then to conserve. It relies very much on the interest and enthusiasm of the farmer to want new diversity, and importantly, not to abandon any old traditional varieties for this new diversity; this could be unique to Vanuatu farmers. Unlike the more targeted approach as illustrated by Samoa, the diversity in the Vanuatu's farmers' field is significantly enhanced, which could have huge benefits in managing climatic variations, and pests and disease outbreaks.

Vanuatu, in common with other Pacific island countries and beyond, has a poor record in sustaining germplasm collections in research stations. To safeguard against the loss in genetic diversity in ex situ (off-farm) germplasm collections, effort is now being made to establish 'collections' in farmers' fields. Vanuatu Agricultural and Technical Centre (VARTC) developed a pilot project to test and evaluate on-farm conservation by introducing new genetic material in Vanuatu's traditional cropping system, and allowing 'natural' distribution of new genetic material through traditional cultural practices of exchanging planting material. The objective was to broaden genetic diversity in village farmers' fields that included varieties that had some key resistant characteristics, thus providing protection against future epidemics and biological disasters. The trials also addressed desired eating and agronomic qualities.

This 'no regrets' adaptation strategy established reservoirs of genetic diversity in taro (*Colocasia spp.)*, yams (*Diascoera spp*, sweet potato (*Ipomoea batatas*)and cassava (*Manihot esculenta*) in 10 villages across Vanuatu. These villages were classified either as yam*)* or taro based. "Yam villages" are generally located in the drier areas of the leeward sides. The 'taro villages' are located at higher attitude or moist windward side of islands. The planting material was produced on VARTC research stations. The bulking up and distribution has been in collaboration with Farm Support Association, a local NGO. New genetic varieties spread naturally through the cultural exchange mechanisms. Two years after the material was distributed to the 10 villages, monitoring of farmer's fields indicated a 86% net gain in the diversity for yam villages and a 61% gain for taro villages, enriching farmers' varietal portfolios; traditional root crops have to be planted and replanted to ensure their maintenance. Taste and texture were most important positive criteria for the adoption of new varieties, whereas the negative agronomic characteristics were the most important criteria for rejecting a variety.

There are significant upfront costs in screening the germplasm material for distribution and establishing new varieties. The costs of that program was Vanuatu Vatu (VUV) 9 million (AUD 70,000), 60 % of which was the vegetative field maintenance, with the remainder for inter island shipping of planting material.

Social and economic assessment

Social and economic assessment of the 'no regrets' strategy of establishing 'reservoirs' of genetic diversity in farmers fields is difficult, as much of the benefits would occur in times of future pest and disease outbreaks, and climate related disasters. The benefits will also depend on the maintenance of the genetic diversity in farmers' fields.

Assuming new varieties are maintained, the benefits can be measured in terms of imported grain if there is a catastrophic loss of subsistence crops. It is estimated on this basis, a mere 5% increase in Vanuatu's grain imports would have a cost of VUV 67 million (AUD 520,000) per annum. A 25% increase would have a cost of VUV 336 million (AUD 2.6 million) per annum. The probability of Vanuatu having a root crop biological disaster over the next decade that resulted in at least a 5% increase in grain imports is seen as quite high.

If the full benefits of in-situ germplasm conservation as a climate change adaptation strategy are to be realised in a reasonable timeframe, then consolidation and expansion of the regional and national germplasm conservation and crop improvement effort is now required beyond a pilot project as this case study emphasises (An outline for such a project, suitable for donor funding is provided in the compendium volume of case studies).

No regrets strategy building on natural risk minimisation strategy

This pilot project demonstrates the potential for building on the traditional practice in the Pacific of maintaining diversity in crop varieties in family gardens, and accessing them in time of need, following changes in climatic and other conditions. By building on the Melanesian cultural practice of openly sharing crop varieties and adopting a proactive 'no regrets' approach to maintaining genetic material in regional and national germplasm collections as well as reservoirs in farmer's fields, it is then possible to ensure the countries have sufficient genetic diversity to help meet their food and nutrition security as well as their income needs in the face of climate change. Such a foundational investment can help meet current disaster risks as well as longer term challenges due to climate change and climate variabilities.

Germplasm conservation and crop improvement programs in Samoa and Vanuatu: lessons for strengthening CCA for food security

The success of the TLB-resistant taro breeding program in Samoa and the proactive 'no regrets' approach to crop germplasm conservation adopted in Vanuatu emphasise the importance of adopting a holistic and systematic approach to climate risk management on several levels, including project or program level, adopting different pathways – addressing current risks (pathway #1 in Figure 3.7), addressing projected risks and being ready for future climatic risks (pathways #2 in Figure 3.7) as well as the longer term foundational institutional level (pathway #4 in Figure 3.8).

They demonstrate that adaptation activity in the agriculture sector that targeted specific 'root causes' of observed disease to climate change, or other specific climate change effects, has very high net economic returns. This is also a direct result of the use of appropriate project cycle based risk management approach, integrating scientific and traditional knowledge, and targeting production-consumption characteristics. The program also highlights several key points about risk management:

- current climatic risks must be urgently addressed, while also preparing for projected changes; and
- holistic risk based planning and management is required, identifying a portfolio program of work that includes specific response activities for local needs, as well as activities that build flexibility and strengthens institutional (national and regional) capacity.

Project cycle based-risk management related lessons

The Samoan TLB-resistant breeding program and the Vanuatu project on introducing and establishing new genetic material in farmer's fields illustrate the importance of:

Prioritising current and preparing for projected risks

- addressing the immediate needs of the communities, as well as their active involvement in the research phase, ensured quick uptake of the planting material;
- adopting both reactive and proactive measures towards dealing with climate change risks;

Risk management approach

- adopting an integrated 'impacts first' and 'vulnerability first approach to risk management;
- developing targeted risk management responses to current risks supported by robust scientific understanding of issues, and good analytical skills to analyse root causes;
- adopting integrated scientific, social science and traditional knowledge to address current and projected biological and climatic risks and to identify appropriate response solutions
- adopting economic CBA and sustainable livelihood frameworks for choosing between adaptation options is relevant even though empirical assessment of economic and social benefits of individual activities, net of costs, may not have done for each of the sub activities (or for that matter may not have been possible given the incremental nature of the trials and experiments). Qualitative assessment of such activities supported by robust scientific knowledge and consumer preference information could have been sufficient support the choices made before the mass distribution of planting material;

Baseline and Foundational investment

The importance of investing in foundational institutions to backstop future needs under alternative climate futures is also highlighted. The earlier investment in the establishment of the CePaCT through the AusAID funded TAROGEN project played a major role establishing the taro collection and taro breeding program.

The CePaCT maintains collections of key traditional crops for the Pacific, including taro, other edible aroids, yam, sweet potato, cassava, and bananas, and it can easily import, multiply and then distribute genetic material as and when required. In the process, CePaCT's presence enables countries to conserve, share, and evaluate their own resources and more effectively take advantage of developments outside the region. This, without doubt, puts the countries in a better stead to produce other climate resistant or climate ready improved crops over time as and when changes in climate are experienced. As such, linked regional and national systems, where present, could enable countries and the region to better manage climate change.

Even though the demand for TLB-resistant taro germplasm is not perceived by the growers as an adaption to climate change, but more, as meeting their current vulnerability to loss in taro crops due to TLB, the approach adopted in this project is easily replicable to produce crops suitable under alternative climate change scenarios. On the other hand, the introduction of new genetic material and the maintenance of this genetic diversity in farmers' fields in Vanuatu has also provided an insurance against similar outbreaks of diseases in Vanuatu, which is likely to occur given the projected changes in climate change in the region.

Prioritising foundational adaption measures

- the need for a combined national and regional germplasm conservation and crop improvement programs and the need for a flexible and sustainable capacity for future crop improvements;
- the relevance of longer term investment in introducing and conserving diversity in crop genetic material in regional and national collections, supplemented by genetic reservoirs in farmers' fields as proactive 'no regrets' strategies for addressing current and projected changes in risks associated with climate change; and
- the importance of taking systematic steps towards producing and distributing adaptation products (disease resistant varieties), provided the steps are sequentially undertake, building and extending previous works, within a logical portfolio of program of work;

Partnership

- the challenges of climate risk could at times be beyond the capacity of any one organisation, and strong partnerships across agencies and countries may required; and
- the importance of strong public-private sector-community partnerships to help keep down the costs of trials and swift adoption by farmers once new varieties showed promise.

Plate 4.1 Climate Change Adaptation and Food security

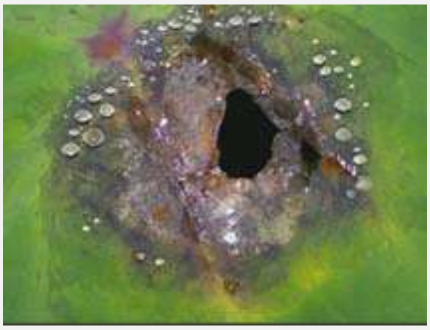
a. **Diversity in Farmers' fields (Photos by Andrew McGregor)**

Taro-based garden, middle bush, Tana, Vanuatu

Yam-based cropping system, Avunamalai, Malo island, Vanuatu

Farmer Bob with his introduced taro variety, Vanuatu

b. Effect of Taro Leaf Blight and taro production



Taro Leaf Blight- Phytophora infection on taro leaves

Samoan farmer with TBL-resistant variety in his garden

Healthy taro for sale once again at the Fugalei Market, Apia, Samoa

c. **Foundational Climate Change Adaptation Strategy : Strengthening Regional and National Germplasm Centres and Crop Breeding Programs (Photos from Mary Taylor**, CePaCT)

Taro tissue collection at the regional germplasm centre, CePaCT, SPC - Suva

Taro breeding field plot, Samoa – Mary Taylor, Director, CePaCT and the USP plant breeder, Tolo Iosefa, USP and other PAPGREN workshop participants

Case study 2: Water security

With climate change expected to negatively impact Pacific island communities through rising sea levels and increased threat of extreme events (drought, storms, and floods), there is an increased potential for climate change to adversely impact water quality and quantity in the Pacific. Tuvalu is a perfect example, where water scarcity and quality is already a major issue with the potential impact of climate change to worsen water security being of high concern. Tuvalu regularly face drought conditions forcing the Tuvalu Government and development partners to provide emergency water supply, the latest of which is the current (September-October 2011) drought affecting all the islands; some islands having very limited reserves of potable water following almost 4 months of drought. In response the Governments of Australia, New Zealand and Japan and the Red Cross have had to come to rescue and provide emergency bottled water and desalination water (SOPAC 2011).

Access to quality freshwater is one of the most important issues for Tuvalu, a country constrained by limited catchment areas to harvest during rainy season and limited ground water. Water and sanitation have been a priority for the Government of Tuvalu since independence in 1978. Officially, it has been highlighted as a priority in the country's national development plan, Te Kakeega II and the Malefatuga Declaration.

The latest forecasts from BOM and CSIRO suggest that Tuvalu can expect a 50-50% change of seeing some changes (-5 to +15%) in average annual rainfall and will likely to have moderately warmer (0.5 to 1.5^0 C) average annual temperatures by 2030. Even if Tuvaluans did not experience significant water shortages due to projected decrease in rainfall, it nonetheless will face water shortages due to demands of an increasing population size (including migration from outer islands), and limited rainwater catchment surfaces and waste-related pollution of ground water. With higher sea levels and intensive king tides already experienced, ground water is further threatened by salt intrusion and contamination from the polluted lagoon. In addition, given the geophysical characteristics of the atoll islands and the regular flooding experienced in Tuvalu, the country can expect regular flooding related hazards; the cost of poor water and sanitation in 2006 for Funafuti residents of some 4,500 people was half a million USD (Lal, et al 2006).

Several development partner funded projects have been implemented in Tuvalu, including those conducted as part of larger regional projects such as the EU Envelope B Water Program, the GEF-funded integrated Water Resource Management (IWRM) project and the UNDP-GEF Pacific Adaptation to Climate Change (PACC) project. The former two projects are being executed through the SOPAC, while the PACC is executed through SPREP.

These three projects target similar issues in water security in Tuvalu although, in some cases, from different directions. Combined, the projects target increases in water availability (e.g., by promoting issues such as water use efficiency or rainwater harvesting) or improvements in water quality (e.g., through activities such as the promotion of composting toilets or improved sanitation practices) (see Table 4.2).

A preliminary review of these three projects highlights several opportunities to strengthen climate change adaptation in water security through, the adoption of explicit risk management steps - which at the core follows adoption of the project cycle based adaptation planning (situation analysis, problem analysis, identification of possible solution options, project feasibility, project design, project implementation and project evaluation (Lal and Holland 2010). Other opportunities emerge in the form of improved coordination of projects and enhanced building of those projects on the results of the earlier projects.

Table 4.2: Nature of three water security projects in Tuvalu: EU Envelope B (SOPAC), GEF-IWRM (SOPAC); and UNDP-GEF-PACC (SPREP)

	Project target	Increased water supply activities	Improved rainwater quality and sanitation more generally activities	Improved water use efficiency (& sanitation) activities	Mainstreaming and Governance activities
EU B-Envelope (2008-2013)	*Improving Drought Period Water Security in Tuvalu* Focus: Improving communal rainwater harvesting as a dry season back-up to household rainwater harvesting approaches, both on the Outer Islands and in Funafuti	300 10,000litre communal rainwater tanks Truck to transport desalinated water in times of drought or water shortages in the homes	Training and awareness-raising, through TANGO	Training and awareness-raising, through TANGO	N/A
GEF-IWRM (2009-2013)	*Sustainable Integrated Water Resources and Wastewater Management* Focus: Sanitation No rainwater harvest tanks supplied but training focussed on water use efficiency Demonstration of compost toilets	N/A	Training and awareness-raising on rainwater treatment and rainwater system maintenance at the household levels.	Commenced installation of composting toilets – 20 installed and 30 more to install.	Identification of legislation and policy issues to be resolved in the near future, such as: engaging community support to draft the building code; review and update the draft national water policy; and, review and update draft water resources plan.

PACC (2011-2013)	*Piloting climate change adaptation in water resources management in Funafuti Island, Tuvalu* Focus: To enhance, and where necessary, develop water infrastructure for the island of Funafuti.	Communal water storage tank at	Training and awareness raising about rainwater treatment, water conservation and rainwater system (roof/guttering) maintenance at the household level (but no water harvest and storage tanks supplied)	Training and awareness-raising on a household basis Expected to introduce composting toilets depending on the outcome of the GEF-IWRM project	PACC Project document refers to : • the revision of water sector policy and incorporation of climate change risk and resilience aspects; ▪ the development of National Climate Change Policy; ▪ the development of guidelines to integrate climate risk into the water sector and its demonstration activities Unclear from the implementation so far as to what specific issues will be addressed. CV&A and SEA has been completed but the draft reports still being finalised.

Risk (Hazard and vulnerability) assessment

All the Project Documents that describe the three water projects make reference to current water scarcity and quality issues in Tuvalu, projected climate changes and the impact of climate change and variability on the quality and supply of water and vulnerability. These assessments, that were largely covered in various Tuvalu Government documents, including Te Kakeenga II, Tuvalu Government 2002; NAPA, First National Communication prepared for the UNFCCC. No further reference to the projected climate change was made in the actual design of the solutions, and it seems that the proponents implicitly used 'vulnerability first' approach to risk assessment. This is likely because such detailed information on changes in rainfall, sea level variations etc was not known at the time of design and only qualitative reference could be made to highlight vulnerability.

Problem and solution identification

From the project documentation that was submitted to the funding agencies, the following observations can be made.

All of the projects refer to the various assessments done by the Tuvalu Government in response to external requirements and results of external activities. The EU Envelop B project's focus can be traced back to the decisions made by Tuvalu government stakeholders, including the National Water and Sanitation Committee, the National Adaptation Plan of Action (NAPA) Country Team, and the International Water Programme National Task Force, and later endorsed by the Prime Minister of Tuvalu (Government of Tuvalu and European Union 2008). Similarly the focus of the GEF-IWRM project can be traced back to the earlier GEF funded project on International Waters Program (IWP) (SOPAC 2007), while some elements of PACC projects could be traced to an be traced to NAPA and the IWP conclusions, as well as the results of the First National Communication report submitted to the UNFCCC. The selection of priority sector for support under PACC was made on the basis of three criteria: the Government's programme priority (as noted for example in the Tuvalu NAPA and Te Kakeenga II); sector with baseline assessment already completed; and, project activities had already been identified that needed implementation and had available co-financing. Specific water management strategies were drawn from the broad problem statements identified in the IWP report and National Communication (UNDP- nd).

The SOPAC supported projects, the EU B-Envelope project and the GEF-IWRM project all undertook current 'on the ground' risk assessment to identify risk management strategies (termed 'water demand and gap analyses and 'diagnostic analysis, respectively). The EU B-Envelop project produced a GIS based household water 'infrastructure' inventory, including information on things such as catchment roof area, state of gutter, etc (Table 4.3).

The PACC project undertook detailed GIS-based assessment of water demand. At present, it is unclear how this assessment was actually used to inform the identification of project activities. Therefore, the link between the water demand assessment and the adaptation options implemented is unclear. The draft SEA and CV&A for the Lofeagai village did identify the specific nature of the underlying 'root causes of the water problem included: although most households had some form of freshwater harvest and storage facility to meet day-to-day water needs, there was limited water reserve, at the household or the village level to meet water demands when there was not rain for over 4 months. At the same time, at least 15% of households had roof areas of less than 50 m^2 needed to meet their average water needs; and about 11% of the households had incomplete gutters, with 6% having no gutters at all. In response the community prioritised the following solutions:

- Install water tanks to individual household
- Community water Cistern
- Upgrade water harvesting system
- Enforce building code

It is though unclear as to the reason behind the community's decision to ask for installation of water tanks in each household when only a small proportion of the HHs were identified to be in particular need of improving their water catchment, and what type of upgrading was being called for. The project though abandoned the idea of providing water tank upgrades to the Lofeagai households, after understanding that the Tuvalu Government had in the pipeline a project to distribute rainwater tanks to each household in the Fogaegai community. Instead the community then decided to target the PACC project resources towards the establishment of community water cistern linked to the new community church

Table 4.3: Risk assessment and project cycle for water security projects in Tuvalu: EU B Envelope (SOPAC), GEF-IWRM (SOPAC); and UNDP-GEF-PACC (SPREP)

	EU Water	GEF- IWRM	PACC project
Diagnostic analysis / Risk analysis	GIS based community survey undertaken to identify current situation with rainwater collection systems and gaps Good GIS based information system established that could be used to identify current gaps in water security and areas to target	Detailed diagnostic analysis in the project design phase. But limited evidence of the use of social and economic information for subsequent project design	GIS based survey of HHs water demand management survey Development of updated GIS model for climate change vulnerability and adaptation mapping; M&E On-the-ground community based risk assessment undertaken based ion 'vulnerability first' assessment reflected in the CV&A assessment undertaken in the Lofeagai community. CV&A and SEA produced useful data at the HH level about on rainwater (e.g. presence and size of tanks and status of roof area and guttering) and sanitation (e.g. composting toilet) needs of Funafuti communities. PACC project focused on water reserve concerns.

Priority adaptation option selection process	Difficult to identify the process and criteria used to select priority actions as little documentation available. Nor could project staff provide any insights on this subject Water catchment and storage to 600 households identified using the GIS water demand and supply gap situation Supplied a new desalination water supply tank for Funafuti - what was the current problem with desalination and supply is though not clear Demonstration compost toilets installed in several locations but no scaling up plan in place	Choice of compost toilet as an adaptation strategy confirmed on the basis of community discussions Criteria for the choice of HHs to target for water tank distribution lacked clarity and transparency issue was raised	Unclear as to the criteria used to decide on the adaption strategies and measures, except key governance related concerns reflected the Tuvalu Government 2002 water management document. CV&A and SEA of the Lofeagai community identified household based water storage tanks as the priority, followed by community based water reserve system. Strengthening community water storage system was selected by the Lofeagai community after ti was learnt that the Tuvlau Government had planned to distribute water tanks to each household. The design could benefit from further technical assessment of the potential for salt water intrusion during king tides.
Project planning and design	Difficult to assess the extent of project planning that was carried out, as documentation of the processes used, and in-country project implementation plan, was not available. Nor did the discussion with project staff in country throw any light on this issue.	Community not involved in the design stage	Difficult to assess the extent of project planning that was carried out, as documentation of the processes used, and in-country project implementation plan, was not available. It is

	There was an important community engagement operation, through TANGO (not sure if it was early enough though to be counted as part of the design stage – I don't have a timeline)		though noted that the choice of strengthening the Lofeagai community reserve followed a detailed CV&A and SEA involving the local stakeholders.
Other activities added during project implementation phase		Harvest of rainwater Water tanks Training needs for rainwater harvest maintenance Institutional and legislative change targeted	

Project target, feasibility assessment and design

The process used to decide on the actual project designs is difficult to ascertain (see details in Table 4.3), as limited documentation on the implementation of the projects could be accessed. The GEF-IWRM project refers to an earlier economic analysis of composting toilet for waste management (Lal, Saloa et al. 2006) to contextualise the focus on establishing compost toilets in that project. It also used the household-based national GIS database on water 'infrastructure' inventory to identify households most vulnerable to dry season water shortages and with inadequately guttered roofing. Presently lacking from the study is now quantitative evidence of how the composting toilet demonstration is helping to underpin the governance strategies, to address activities unfinished by the IWP.

By comparison, the PACC project proposes an economic assessment of the pilot work conducted at Lofeagai and Vaiaku sites. The purpose of this assessment is presently unclear, especially given that procurement for constructions material has already begun. The proposed construction of the underground cistern as a water storage could benefit from further technical assessment, including risks of water contamination during king tides. Such an assessment could help identify appropriate design of the cistern that can help minimise the scope of such contamination during king tides and associated pollution from the nearby burrow pits; the potential for such contamination was highlighted during community consultation the potential risk of contamination during king tides. Nevertheless, an economic analysis will create opportunities for potential ongoing refinement of the projects and may even identify new design options for the storage tank. In fact, these objectives have not yet been articulated in PACC documentation but the opportunities do exist.

Other project cycle-related questions concerning the PACC project arise (see Table 4.4) when considering some other PACC activities identified for Tuvalu. Due the limited availability of documentation, these issues are difficult to assess or comment on.

Table 4.4 PACC activities noted in the Tuvalu's-PACC project document and key questions that need further attention

Activities identified	*Key questions that arise*
Develop a guide for climate proofing existing water reservoirs and water tanks taking into consideration current and future changes in climate	*Is retrofitting the most cost effective option?* *What other options were considered?* *How was the retrofitting options selected?*
Improve knowledge of available water resources, demand and prediction of extreme events	*How was this information used to decide on adaptation strategy?*
Develop and use climate information and data for water resources planning and management	*How critical is more detailed climate information to inform the level/ scale of resource planning decisions required in country?*

Design and demonstrating alternative water supply systems using energy efficient technologies	*What are the energy efficient water supply technologies/ systems?* *Does Tuvalu have the resources to 'design alternative water supply systems using energy efficient technologies?* *Is this the appropriate project question?* *How cost effective are such technologies for cash constrained households and communities?*
Land use planning and water reserves - protection of water storage facilities from contamination	*Is land use planning the priority solution for the current contamination of water storage facilities; and on which island?*
Construction of underground water cistern at the Lofeagai community church grounds	*How was this option selected and what type of assessment was done before this option was selected and implemented?*

Cost benefit analysis of the adaptation projects

Economic analysis of the three Tuvalu project was confounded by a number of issues. First, the absence of a detailed probability distribution on the impact of different climate change scenarios on quality and quantity of water supply meant that a probabilistic CBA was not possible. Instead, only a deterministic CBA could be attempted, together with sensitivity analysis around key economic assumptions. The three projects are still ongoing and thus the CBA is largely ex-ante in nature, although the key parameters are based on current estimates obtained from the country, together with proxies drawn from published literature.

Second, there is a considerable overlap in the objectives of each of the projects in Tuvalu, making it hard to distinguish the contribution of each project to common outcomes. For example, all projects include objectives to improve water harvesting, thus improving sanitation and water use efficiency. However, it is difficult to identify the percentage of total improved water quality, for example, that is attributable to any one project versus another. Consequently, benefits could only be considered collectively. Third, due to the multitude of other water projects also underway in Tuvalu at the same time as the three assessed, it was difficult to identify the likely situation in Tuvalu had the three case study projects not existed ('without scenario'). This is critical for assessing the potential contribution of the three projects. As a consequence, a set of assumptions had to be made about the likely without scenario for Tuvalu (Table 4.5).

Table 4.5. 'With and Without' benefits and costs of the three water projects in Tuvalu

A: Without the projects	B: With the projects (for the period 2008-2028)
Costs	
▪ Imported bottled water purchases ▪ Use of expensive desalination plant ▪ Water-borne and water-related health costs ▪ Lack of water security and associated costs of water shortages/ drought periods	▪ Financial costs of initial project implementation and continued incremental investments over time (e.g. for maintenance and awareness-raising).
Benefits	
▪ None.	▪ Improved sanitation and associated avoided water-borne and water-related health costs ▪ Reduced expenditure on imported bottled water consumption ▪ Reduced expenditure on desalinated water consumption ▪ Non-quantifiable benefits such as psychological peace of mind due to secure water supply.

On the basis of these assumptions, deterministic CBA was attempted using data obtained from government representatives, communities affected by the projects and project staff from SPREP and SOPAC, as well as project documents and project data. A partial CBA of the three water projects considered in Tuvalu suggests that the nominal benefits from they could reduce current risks to water security by about $20 m over the 20 year period. In economic terms the net economic benefits is between AUD$6.7 -15.4 million using a range of 3% to 10% discount rate used (Table 4.6); net benefit estimates were most sensitive to the discount rates used.

Table 4.6 Potential combined net benefits from the three water projects

Benefits	Nominal Value (A$)	Value (A$, discounted at 3%)	Value (A$, discounted at 7%)	Value (A$, discounted at 10%)
Health improvements	6,106,186	2,066,237	2,788,244	2,104,948
5% reduction bottled water purchases	27,966	19,528	12,770	9,641
Water supply benefits from EU B-Envelope	4,990,428	3614534.7	2,492,176	1,961,956
Water supply benefits from GEF-IWRM	288,864	203,013	134,247	102,385
Water supply benefits from PACC	239,259	167,785	210,975	82,573
Benefits from reduced water bucket & desalinated water collection during droughts	12,336,625	8,806,550	5,975,255	4,519,461
Total Benefits	19,485,574	17,075 097	11,512,473	8,922, 563
Cost	4,503,754	1,631,454	1,689,558	2,162,205
Net benefits	19,485,574	15,443,643	9,822,915	6,760,358
BCR	5.3	10.5	6.8	4..1

The CBA exercise conducted highlights the difficulties in trying to undertake a quantitative assessment of climate change adaptation options in the absence of effective baseline information. It underscores the value of building into the design of adaptation project the identification of baseline data needed to assess and monitor projects. Running project ideas through a simple cost-benefit framework when considering potential projects could potentially contribute in this respect. The baseline data identified would then allow for more targeted quantitative appraisal of project impacts ('environmental status' or 'stress reduction indicators' indicators) and allow for more their directed guidance compared to on – say – consideration of expenditure made to date or observing where planned activities have indeed been conducted ('process indicators'). The use of CBA framework is also useful to guide aspects of the 'vulnerability first' approach to risk management

Monitoring and evaluation and long term sustainability

At this stage, it is difficult to comment substantively on the sustainability of the three Tuvalu water projects assessed beyond general intent and advocacy, since none of the projects included specific outcomes (environmental status) indicators to assess the impacts of the projects. Rather, they focused largely on process indicators (ticking off when an activity has been completed), although some behaviour change (stress reduction) indicators were included.

In conclusion, the water case study was based on the three independent water security adaptation projects in Tuvalu which had complementary objectives. The case study highlights several opportunities for the design of climate change projects and the potential role for social and economic assessment within that:

- A 'vulnerability first' approach to CCA may offer an opportunity to design and more effectively monitor and assess adaptation projects where country specific empirical data about climate change science, including inherent uncertainties, and their impacts is limited. It can help identify appropriate adaptation measures for consideration.
- Deterministic ex ante CBA of adaptation project, or a portfolio of projects, is feasible, if the project is designed such that the sum of the activities can deliver on the expected benefits and these can be clearly articulated and benefits and costs can be quantified. However, as a minimum, a 'without' project empirical information about the social and economic well being, and expected change in the well being as a result of the 'with' adaptation project is required to do a quantitative CBA.
- In the absence of a clearly defined scope and project boundary, only indicative net benefit assessment may be feasible provided key assumptions are made, and sensitivity analysis is used to give an indication of the range of benefits and costs.
- As a minimum, CBA can help systematically (i) inform the design and monitoring of adaptation projects (ii) structure benefits and cost assessment 'with and without' the project, as a component of the 'vulnerability first' approach to CCA decision-making.
- Knowledge-based decision-making processes using project cycle based risk management could be improved by strengthening capacity in the use of such analytical and decision-making processes across all levels.

Case Study 3: Sea-level rise and relocation of coastal communities

Relocation as a climate change adaptation strategy has been seriously considered since projections about sea level rise came to the forefront. Global warming induced sea level rise scenarios often raises many emotive arguments in terms of loss of basic human rights, watching the islands 'drown' and calls for the protection of climate refugees (see Farbotko 2010). Whether the increased risk of coastal erosion, storm surges and or coastal inundation is caused by islands sinking due to tectonic shifts, such as is the case in the Torba Province, Vanuatu (Ballu, Bouin et al. 2011) geomorphic change in Vanuatu (Webb and Kench 2010) or rising sea level due to climate change (Mcleod, Hinkel et al. 2010), the challenge of making an appropriate adaptation decision remains.

In 2005, under the Canadian International Development Agency (CIDA) Funding, SPREP assisted the Vanuatu Government to implement a climate change adaptation project aimed at assisting a coastal village on the island of Tegua to relocate. Lateu, a coastal village in the Torres Province, involving about 10 households (with reportedly about 100 people) was relocated from their existing location to a nearby site on the same island. Process involved households removing their sleeping house and cooking house and rebuilding them at the new site. The key objective behind the relocation was to reduce the risks faced by the villagers from regular coastal inundation, causing damage to their homes and assets, poor health, and general inconvenience.

The purpose of this case study was to review the nature of social and economic assessment that informed the choice of relocation as an option and the choice of the exact relocation site, covering issues such as:

- The nature of risk analysis undertaken
- Approach used to identify management/ adaption measures, select adaptation response and associated costs
- The nature of risk reduction analysis was undertaken before implementation – i.e. estimated benefits of reducing risks ; and
- Expost estimation of economic costs and benefits associated with relocation.

The broader implications of relocation as a climate change adaptation strategy in the Pacific have also been outlined.

This assessment is based on the review of CBDAMPIC documents made available by the project team, Taito Nakalevu of SPREP and Brian Phillips, of the Climate Change Unit, as well as those accessed from the web. A specific field visit to the Tegua island was also conducted in April 2011 for discussion with the community members who were involved in the relocation; this field work was undertaken jointly with Ms Olivia Warwick and the description of the detailed social assessment is reported in Warwick (2011).

Background

With the Canadian International Development Agency (CIDA) support, SPREP coordinated and executed a CAN $2.2 million funded *Capacity Building for Development of Adaptation Measures in the Pacific Island Countries* (CBDAMPIC, in four countries, Samoa, Cook Islands, Fiji and Vanuatu.

The project had two main objectives: to increase the capacity of Pacific Island government institutions to deal with climate change risks through mainstreaming, and to increase the resilience of communities to climate related risks through implementation of adaptation recommendations (Nakalevu, Carruthers et al. 2005). A two tiered, 'top-down' and a "bottom-up" approach was adopted in the project, linking government institutions with communities. The project involved:

- capacity development at the national level the concept of mainstreaming climate change adaptation into institutional frameworks, sectoral policies and ministries' operational plans; and
- community level capacity development in using a participatory approach to assess and evaluate vulnerability to climate change and adaptation options in order to plan and implement locally appropriate adaptation activities.

In Vanuatu, both these capacity development exercises were indirectly provided through 'hands on engagement' in the design and implementation of the relocation of the Lateu village.

Risk analysis and identification of adaptation options

The CIDA funded project essentially adopted a 'vulnerability first' approach to risk management, making reference to the broad climate change futures projected for the country, and involving key stakeholder groups. The community based participatory risk assessment process involved Tegua villagers, key government agencies, such as the Department of Geology, Mines and Rural Water Supplies, Department of Health, Department of Meteorology, the Department of Environment, and the Torba Provincial Government representative, as well as the Melanesian Church.

The project team conducted workshops in the village and undertook a community vulnerability and adaptation (CV&A) assessment using a process designed by SPREP (Nakalevu 2006). The CV&A essentially mirrors key elements of the basic project cycle steps (Adaptation Context assessment; diagnostic assessment; assessment and evaluation; development; implementation and monitoring), and builds on the principles of rapid rural assessment (RRA); participatory learning and action (PLA) and Comprehensive Hazard and Risk Management tools advocated in the Pacific (Nakalevu 2006). Several environmental hazards were identified including sinking of islands due to earthquakes, flooding during king rides and regular inundation of the village and storm surges in times of high tides and strong wind (Table 4.7). However, the project was reported globally to be the first community 'migration'/ relocation due to climate change risks (e.g.Caldwell 2005; Environment News Service 2005).

Table 4.7 Key results of the V&A assessment, Lateu village

Hazards	Impacts	Effects
• Coastal erosion of 50 meters (or 2.5 m/yr) • Seal level rise • Geological processes • King tides and high	• Raised underground water lens • Village surrounded by permanent (?)pools of water near the swap • Village grounds and housing area regularly	• Deteriorating housing rapidly, • Prevents or completely stops the use of cooking place; • Dampness in the house • Pit toilets overflow , contaminating the only underground water well • Water-borne and insect borne

spring tides and south-westerly winds	flooded	diseases, including malaria, diarrhoea and skin infections, especially among children.
Source: Phillips (nd)		

Climate change risk perception and risk reduction priorities

Although the project was identified by SPREP and the Department of Environment as an initiative aimed at addressing the risk of sea level rise and associated flooding, for the community this was also an opportunity to address their key development need – access to fresh water. This was revealed during the field visit conducted by the IUCN team in April 2011. Using a semi-structured survey of the community households, including focus group discussion and individual discussions, community perceptions and views about climate change risks, reasons for the relocation, and benefits of the relocation was gauged.

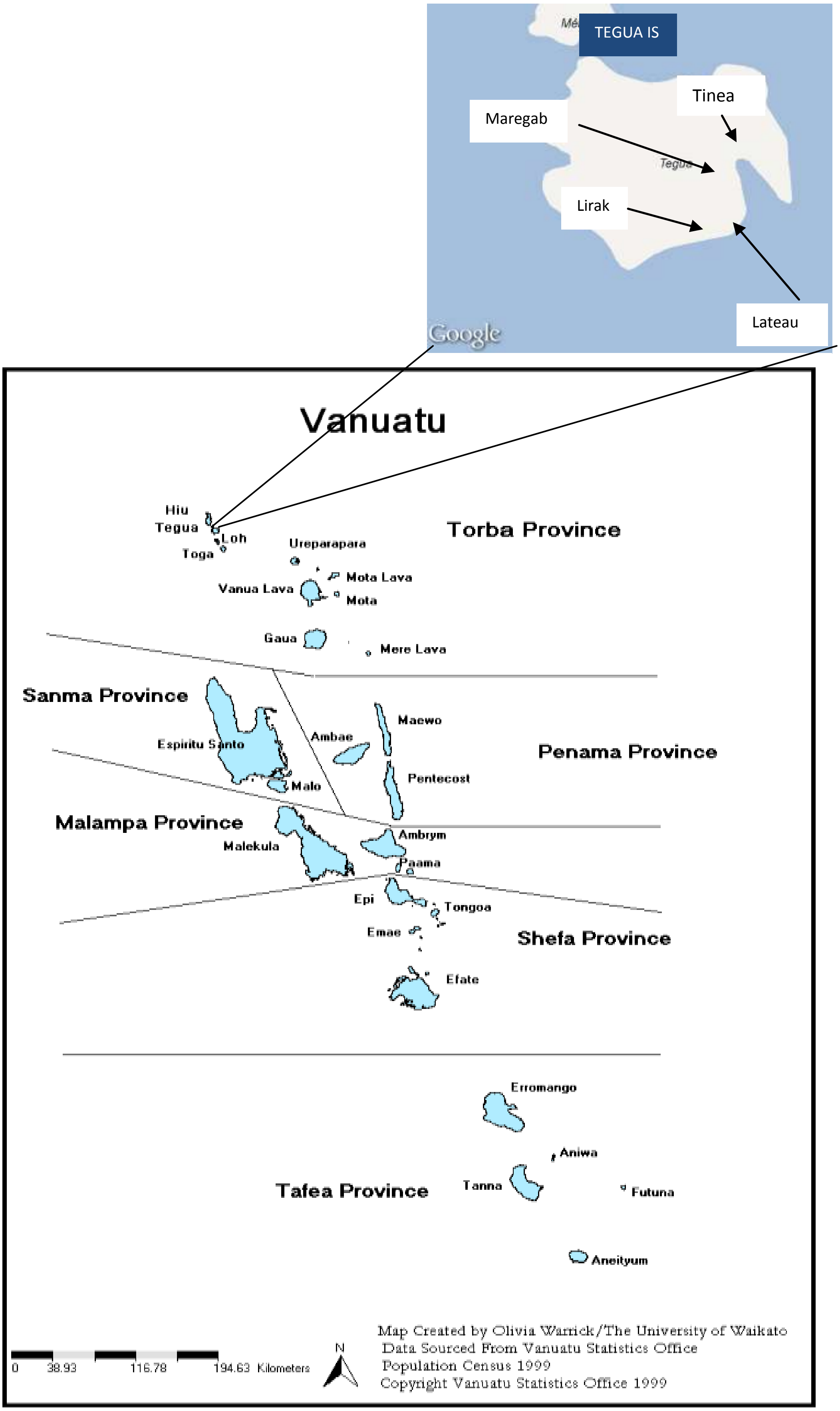
Community members noted that they were initially reluctant to relocate, because the Lateu village had good supply of freshwater harvested from a catchment roof and communal water tank supplied by the Government's Rural Water Supplies. The community decided to consider relocation only after the Project team promised to supply (under the CIDA funding) additional "white man's" houses in the form of women's club, aid post, plus additional water tanks (Jean Piere Laloya, pers comm.). Thus it seems that although flooding was a concern, their priority was for the community was secure water supply (i.e. their main concern was the current disaster risks or pathway #1 noted in Figure 3.8).

It may be possible that the community may have implicitly had a lover concern for flooding, as the flooding problems actually started after the major 1997 earthquake whereas water security cncern has been a constant issue; since 199 the island has believed to have risen once again due to tectonic shifts (this phenomenon was confirmed for a nearby island of Loh in the same province recently by (Ballu, Bouin et al. 2011). It is also possible that since the variations in the sea level rise and storm surges are experienced regularly in the South Pacific due to ENSO events (BOM and CSIRO 2011 (draft)), any changes in climate may not have become part of their consciousness. Yet the community has been made aware of the concept of climate change through radio programs and the visit by the project team. The villagers though did comment on some changes they have observed in the cropping and fishing cycles, including that some crops such as yams don't grow as well as previously with the flowering patterns of many trees such as oranges, breadfruit and *nandao* (a fleshy fruit) changing to the extent of not flowering at all and therefore having less fruit. These are usually attributed to changing climatic conditions in other parts of the Pacific (Bourke 2010).

Selection of preferred options

Relocation it seems was not a new concept to the Lateu people, as the village had started talking about relocating it seems as far back as the early 1970s. At that stage, the community had talked about moving to Tenea, a site some 1oo metres from the Lateu village site; the same site that many are now rethinking of moving to. Tenea is also the site where one of the villagers had decided to move to when the rest of the community moved across to Lirak (Figure 4.1).

Figure 4.1 Map of Vanuatu with Tegua island insert



The community had three options to choose from – Lirak, the chosen site by the government and chief; Tenia, the site preferred by the community; and Meregab, the site further up the hill and closer to the community gardens. These three options had slightly different characteristics (Table 4.8).

Of the three alternatives, most people preferred Tenea, as it had all the characteristics found at the Lirak site, with the added advantage of easier ground for making houses, and gardens. The Tenea site was a little (5-10 minutes) further away from the coastal freshwater spring used by families to wash their clothes. However, from the documents that could be accessed it is not clear if villagers explicitly considered the pros and cons of the alternative sites before a decision was made. The choice of Lirak over Tenea could be justified for many reasons including (as emphasised by the village Chief) the closeness to coastal springs and therefore less work for women for washing, bathing etc. and closeness to the sea and the beach. However there are also significant advantages of the Tenea site where most of the villagers preferred to move including the fact that it was only 10 to 15 minutes from the gardens, only a further 10 minute walk to the springs (and slightly further to the sea) with easy ground to dig and most importantly less vulnerable to the impacts of sea level rise and storm surges.

Based on the informal household surveys conducted in April 2011, villagers apparently agreed to move to the Lirak site to maintain their social harmony as the traditional chief had already started clearing a site at Lirak to construct his house. For some villagers, this site, although better than the Lateu site, was not ideal as there was not much land for building additional homes for adult sons, and the Lateu ground was difficult to work. Many households are now thinking of once again relocating, but this time to Tenea.

Project design

Villagers rebuilt their homes using their own traditional designs and building material sourced from the bush. A few households decided to raise their houses and build on short stilts, perhaps in response to their experience of flooding at the Latea site. The detailed design of the 'white man's' house (guest house, kindergarten, and house of the local women's association) was developed by the Government draughtsman, and build under the supervision of a builder contracted under the project. The material was purchased by the project team and shipped from near-by island of Santo.

One key feature of this process was that while participatory processes were used in the initial consultation and in the CV&A assessment, they do not appear to have been used to inform the design of 'white man's' houses, including the selection of the posts for the house (this could not be confirmed as the project documents accessed did not cover the issue of decision-making process used). One of the consequences of non-participatory processes was the inappropriate use of 'white wood', a soft wood timber that is not suited for the conditions found on the island (Jean Piere Laloya, pers comm). Similar rebuilding of the church (Plate 4.3 seemed to have been needed because of the tall-building design not so suited for the area (Jean-Peier Laoya, pers comm.; see Plate 4.3.3.a). When further explored with the villagers, it seems that the communities 'went along' with the project teams decisions even though they were aware that the 'white wood' was not a suitable material for their island. Three years later the villagers had to replace the posts with hardwood sourced from their forests, as the original posts had rotted away (see Plate 4.3.3 b). It was not possible to confirm who and how the decision was made about the selection of construction material, as the original department files could not be located; they seem to have been displaced in the relocation of the department to their government offices.

According to Kouwenhoven and others Lirak village could also be better prepared for projected climate changes, had the design of the water tanks and catchment area also had taken into account likely water needs in times of drought (Kouwenhoven and Cheatham 2006). The current water tank size and catchment areas (6000 litre each with a catchment area of about 35 m^2) could provide water for about 7 weeks of dry weather for the village; an assessment that Kouwenhoven and others had done using information and models available with the Department of Meteorology.

Expost evaluation of the relocation project

It is not possible to undertake expost evaluation of the CBDAMPIC relocation as little empirical information about original conditions were reported and the project did not explicitly consider alternative designs or options (Kouwenhoven and Cheatham 2006). Qualitative assessment immediately after the project was completed, does give an insight into the nature of benefits that the communities highlighted. Anecdotally, the villagers noted the decreased in the incidence of water and insect borne diseases, reported in Table 4.8. It is though difficult to attribute the change in the number of malaria cases solely to the relocation as a Torres-wide malaria eradication programme was started in 2006. It is likely that the relocation project may have contributed to the reduction in malaria and other diseases risk at Lirak, which has more open space than Lateu, less sitting water, and local respondents believed there were fewer mosquitoes around. Villagers also reported limited flooding, except for the households located at the foot hills; water though did not stay for long and houses did not rot away as quickly as they used to.

Plate 4.3 Climate Change Adaptation: Lateu Community Relocation

4.3.1 Orignal site, Lateu before the relocation under the CBDAMPIC project

a. Old Lateu site where the village had to relocate from (Phillip nd)

b. House perched on rocks to accommodate small levels of flooding (Phillip nd)

c. Old water catchment shed at the Lateu village site

d. Village girls walking towards the Lateau village from Lirak, a distance of less than 100 metres

4.3.2 Relocation of Lateu community under the CBDAMPIC project, Lirak and Tinea sites

a. House construction at the Lirak site, showing hard coralline ground Lirak, with relatively poor soils

b. Watch catchment and storage, Lirak

c. Some households chose to build their houses on stilts at the new site, Lirak

d. Tenea site where one household moved to instead of Lirak; spacious Tinea site with relatively better soil conditions

4.3.3. Apparent result of maladaptation from the use of timber not suitable for local conditions the Lirak site

a. Church that had to be rebuild using local design

New hardwood post added to the roof beside the rotted original white-wood post

b. Posts in 'white man's' houses rotted away and needed to be supported using local hard wood shown here.

4.3.4. Tectonic shifts resulting in adjacent island of Loh sinking (resulting in death of coconut trees, and then rising again leaving behind coconut stumps, and colonisation of the area by mangrove species.

Coconut trees that died as a result on permanently inundated with sea water, following the 'sinking of the island of Loh

Mangrove seeding germination following the 'rise' of the island following subsequent earthquakes

Table 4.8 Key characteristics of the three alternative sites for relocation, and the original village site, Lateu

Characteristics	**Lateu – Original village site**	**Lirak**	**Tenea**	**Meregab**
Location		500 meters down the coast from Lateu and approx. 30m inland where the majority of the community now live	An alternative relocation site chosen prior to the relocation project where one family now lives. About 150m inland, and 10 mins walk from Lateu to Lirak	A site up the hill – in an elevated area in the middle of the island where the gardens are located.
Distance from sea	Adjacent	Adjacent but a few metres from the sea on the north west direction	Further away, about 10 minutes walk from the coast	Up the hill (traditional location of the missionary influence)
Distance from coastal spring water	Adjacent	Adjacent but a few metres from the sea on the north west direction (extra 2-3 minutes)	Further away, about 10 minutes walk from the coast, and an extra 3-5 minutes from the springs	A distance and hike up hilly terrain
Flooding	Every heavy rain & high tide	Some flooding; but clears quickly	Nil	N/a
Ease of digging the ground	Coralline and difficult to dig	Coralline and difficult to dig; same as Lateu	Sandy, easy to dig	Easy ground to work
Distance to hill/ food gardens	25-30 minutes	25-30 minutes	10-15 minutes (more space and better ground near the house)	2-3 minutes
Cash income sources	Cash crops: coconut crabs, copra. Lobster, kava, root crops	Same as at Lateu: Cash crops: coconut crabs, copra. Lobster, kava, root crops	Cash crops: Same as at Lateu: coconut crabs, copra. Lobster, kava, root crops	Cash crops: Same as at Lateu: coconut crabs, copra. Lobster, kava, root crops
Access to well water	Water table <50cm	Water table <50cm	Deeper well (??)	

Concluding remarks

For the people of Tegua island relocation was not a major issue, as they had been thinking of moving for some time. For the community, flooding during storm surges and heavy rainfall was experienced particularly after the 1997 earthquake, when several islands in the Torba Province had been reported to ‘sink. For the community, while the recent increased risks may not have been directly attributable to climate change it nonetheless was reported as such globally. Climate change may have contributed to the increased flooding of the village, although this is difficult to demonstrate in the absence of good data and country specific climate models.

Taking a holistic approach to risk management, the CBDAMPIC project was able to address the current risks and prepare villagers for further environmental threats probably what may be expected at least in the short term. This relocation project highlights several issues of relevance to future adaptation projects including:

- Local engagement and consultation is essential in learning about peoples experiences, what people want and project designs that could benefit from the local knowledge that they possess and can pass on.
- Local level CV&A can assist in assessing how concerned people are about climate change and what sort of information exists and new information that may be necessary to encourage fully informed decision making. At the same time, it is important that stakeholders are involved throughout all stages of project cycle to avoid maladaptation, changes in the natural or human systems that inadvertently increase vulnerability.
- Careful consideration of the existing governance processes, including traditional governance, is important in order to address the decision making procedure, ensure equitable decision-making, encourage fairness and social justice and to emphasise the importance of leadership in contributing to these processes.
- In the absence of baseline empirical information, the importance of undertaking hazard mapping with local communities can serve as a second best strategy; essentially undertaking the first few steps of the ‘vulnerability first’ approach to risk management;
- A systematic application of the project cycle-based risk management framework, together with CBA as a process can still assist in informed decision making, by explicitly considering many economic and social costs and benefits, expressed qualitative and or quantitatively.

International literature also highlights that other issues that may also need to be considered in the broader context of climate change induced relocation and when dealing with climate refugees, including:

- Other drivers of vulnerability, such as geohazard events, population growth and movement, et.
- Ownership of land - Although in this project, relocation was to their own land, the situation can be more complex when relocation involves moving to land owned by other communities. In which case lengthy negotiation for access to land may be necessary, or governments may need to consider acquiring land to resettle people. The important of also addressing the legalities of protection of future refugees is paramount. Fairness, justice, sovereignty and security all need to be addressed in the adaptation policies, particularly

where large communities are involved and there are different interest groups as well as different categories of disadvantage groups.

Case study 4: Climate proofing of coastal road infrastructure, Western Guadalcanal, Solomon Islands

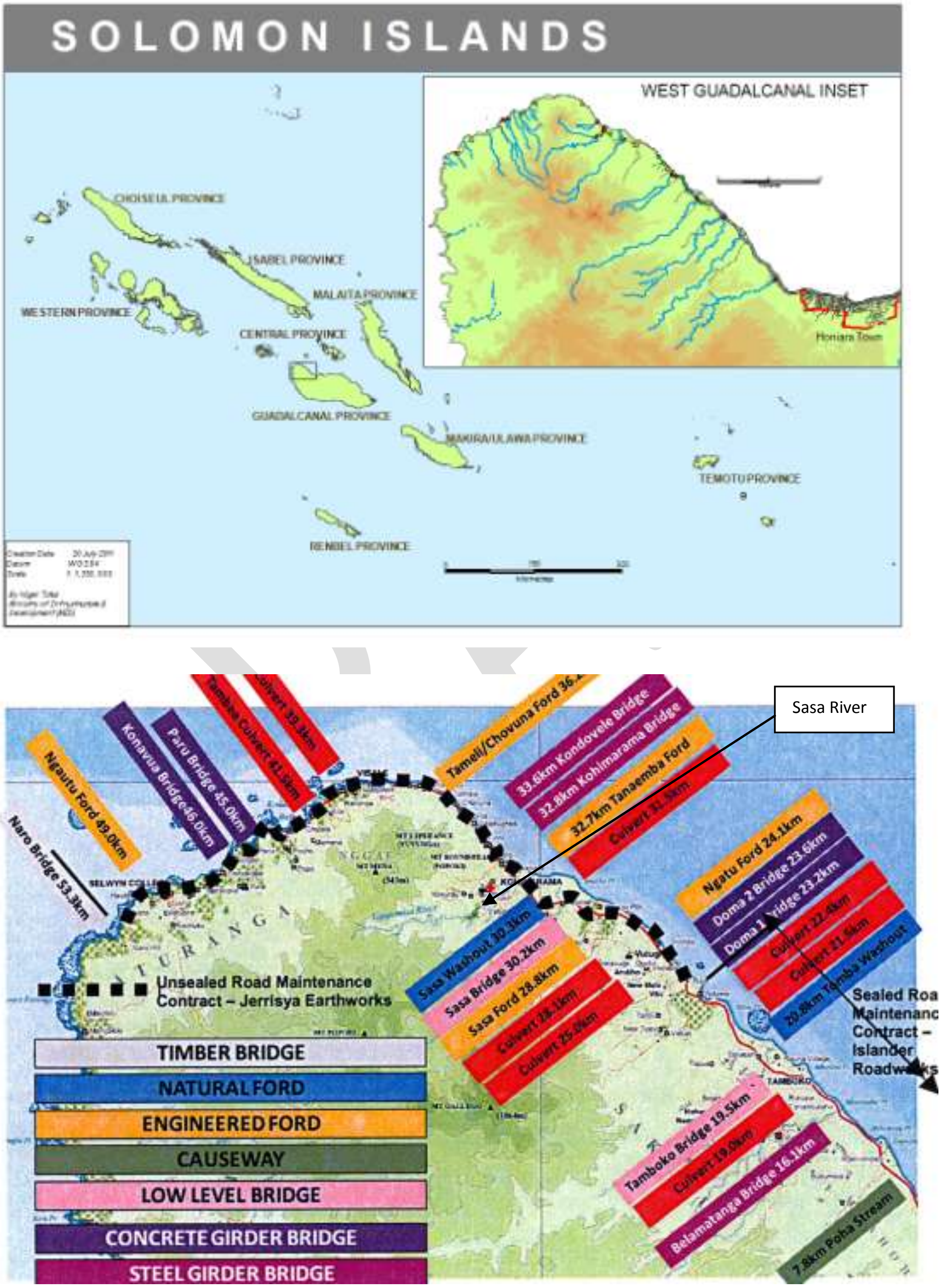
The Solomon Islands are located just south of the equator and as such regularly experience climate related extreme events, including tropical cyclone-related heavy rains, damaging winds, and storm surges. Storms and associated flooding comprised eighty percent of all reported disasters between 1980-2010. In total, these reported climate-related events affected about 300,000 people and killed at least 180 people (prevention webnet.html, accessed October, 2, 2011).

Included in this is the 1-in-50 year 2009 January-February heavy rains that caused extensive flooding in the western and eastern parts of Guadalcanal, including the area between White River and Naro Hill – Selwyn College (Figure 4.1). During this event the heavy rains combined with high tides, and high winds, the road between White River and Naro Hill experienced significant damage to existing bridges, wet crossings, engineering fords, causeways, extended bridge slabs and bridge wing walls. Heavy scouring took place at pile foundations of access for the local communities as well as physical damage to the road itself. The local communities also suffered widespread damage to housing and food gardens, and an estimated 2,000 people were displaced and 13 people killed or drowned (Cardno/SIG Report NO 40, June 2009). At Sassa Bridge and Tamboka Bridges, flood waters had left behind huge logs and debris extending to some 200m on the upstream of the widened river causing river diversion of about 50m of the existing structure (See Plate4.4.1). The rivers and streams in West Guadalcanal flow over soft alluvial soils; this is an area that is is renowned for water courses to regularly change during rainy season, with debris flows coming down the hills often compounding the problem.

In response to regular flooding and other such damages, the Solomon Islands Government with the assistance of ADB, the Government of Australia and the Government of New Zealand, undertook a programme of road rehabilitation, Solomon Islands Road Improvement Project (SIRIP). The SIRP's goal was to rehabilitate the roads to be able to withstand a higher category of weather event. The original SIRIP 2 project was designed to repair and improve the road between White River and Naro Hill, which was extended to Selwyn College following the January-February 2009 floods.

In addition, the original SIRIP 2 project was designed in response to current disaster risks (Cardno Acil 2009). This was subsequently revisited following the 2010 floods to reflect projected increases in climate risk consideration in the rehabilitation design before actual construction works began (Cardno Acil 2010 b).

Figure 4.2: Map of Solomon Island Road Improvement Project (SIRIP 2): Western Guadalcanal Road Improvement Project



Source: (Cardno Acil 2009).

In this review, the original SIRIP 2 project plus the additional climate proofing activity are treated together to discuss following key issues:

- Approaches used to analyse current climatic risks, risk thresholds and projected climate change related risks;
- Approach used to identify, analyse and select appropriate current risk reduction option; and
- Approach used to identify, and select risk reduction option for climate proofing of the road infrastructure improvements.

Climate risk management process

The ADB-SIG project development followed the key steps of the standard risk assessment steps outlined in Figure 3.3. The Cardno Acil Ltd, the consultant team hired to undertake the initial project design as well as subsequently implement the SIRIP, undertook:

- key context analysis in relation to hazards and identification of problems and possible solutions
- assessing solutions measures and selecting preferred choice based on key criteria
- undertaking cost benefit analysis
- project design
- climate change scenario analysis and 'climate proofing' of preferred option

The SIRIP 2 project was designed to reduce the impacts of regular high intensity precipitation and associated flooding on key road infrastructure in the Western Guadalcanal, including culverts, bridges, causeways and roads. The terrain is also subject to heavy river flows, changing rivers and stream location as well as associated scouring of land around streams, rivers and physical infrastructures, compounded by large volume of debris coming down the main rivers and streams. Deforestation, combined with poor forest management practices, is a major source of logs in the debris flows, blocking main streams and rivers (Bonte-Grapentin 2009); it not uncommon to find rivers and streams finding new and often unpredictable routes (Photo 4.4.1).

Current risk and risk reduction analysis

Scientific impact assessment formed the basis of the current and projected hazard and risk assessment, as well as risk reduction assessment.

Hazard analysis was conducted using hydraulic [hydrology] modelling-based analysis to produce estimates of river flow velocity, depth, frequency and flooding at each of the stream/ river crossing. In the absence of stream flow modelling information available for Solomon islands, the consultants used simplified modelling of the available rainfall data for Honiara to determine daily rainfall pattern required to produce a 1-in-2 year (or a 2 year return period), 1-in-10 year (10 year return period), 1-in-50 (50 year return period) and 1-in-100 year (100 year return period) rainfall events; the 2009 rainfall was considered to be 1-in-50 year event (Cardno Acil 2009) (Table 4.9).

Plate 4.4.1 Sasa Bridge immediately following the 2009 heavy precipitation and flooding

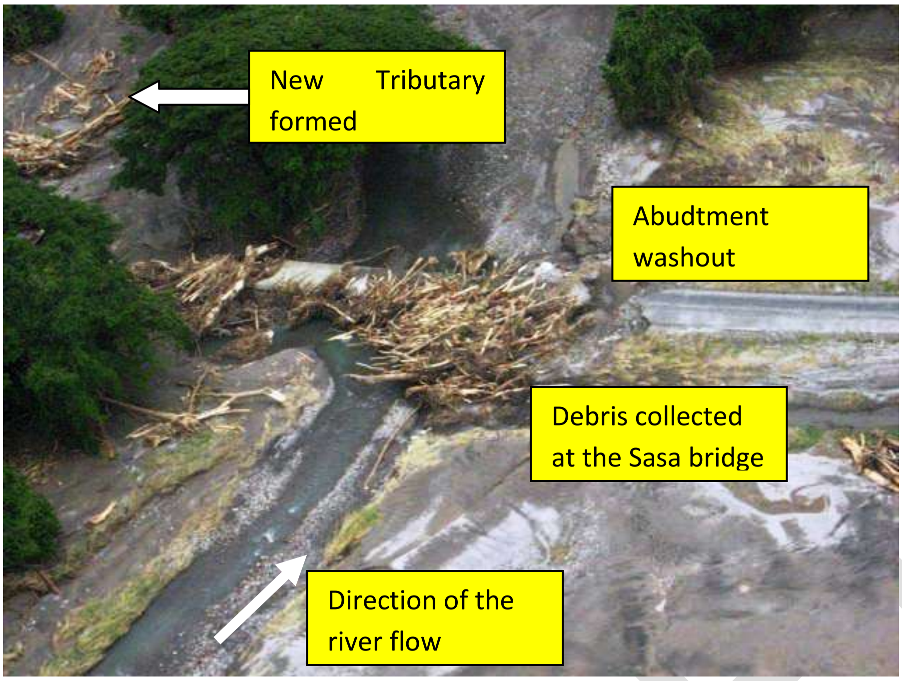


Photo: Terry Telford, Cardno Acil Ltd.

Table 4.9 Modelling based rainfall pattern associated with various extreme rainfall events

Rainfall extreme event (or return periods)	Maximum rainfall (mm/day)	Daily rainfall intensity (mm/hr)
1 in 2 year (2 year)	106.1	4.4
1 in 10 year (10 year)	194.6	8.1
1 in 50 year (50 year)	254.0	10.6
1 in 100 year (100 year)	282.1	11.8
Source: (Table II.1 Cardno Acil 2009)		

The project team used the 'Rational Method' for the estimation of flood flows at stream crossing for 2, 10, 50, and 100 year return periods. This analysis together with a compensatory factor recommended for PNG (SMEC 1990), the team determined the respective flood levels and velocity of river flows at the crossings associated with the respective return periods and for each of the rivers and streams in the project area. Using this information, flooding regimes for each river and stream was estimated, despite noting that *the accuracy of the flood predictions based on the above method [Rational Method] is unknown (p 10, Cardno Acil 2009).* The results of the Rational Method were then used to determine the design of culverts and bridges to cope with 1 in 10 year event; the effect of debris flow on the structural designs was though not considered.

It is, however, unusual to see the use of the PNG flooding formulae without any adjustment to suit the SI conditions (as noted inCardno Acil 2009) particularly when most areas of PNG does not face high intensity rainfalls produced by tropical cyclones common in the Solomon Islands; during heavy precipitation in the Solomon Islands there is rapid hydrological response, producing extraordinary river discharges. Designs based on the PNG modelling could be suboptimal as they may more be suitable for lower flows and lower velocities than what is the situation in the Solomon Islands (Hall 1984). Unfortunately, it was beyond the scope of this small review study to assess what difference in flow modelling could arise if the ADB consultants had used the locally available rainfall data and the river flow modelling done by JICA in 2000 for Lungga and some other eastern rivers in the Guadalcanal Province, or the river flow modelling results done by JICA in 2000 (JICA 2001).

The hazard risk assessment also did not seem to have explicitly taken into account other geophysical characteristics of the Guadalcanal catchments, rivers and stream flows, and flood plains. For example, significant shifts in soft alluvial plains are commonly experienced in the Guadalcanal flood plains, resulting in regular redirection of rivers and streams, abatement washouts, and scouring of soils around infrastructures, compounded particularly when large amounts of debris come down the catchment (Cardno Acil 2009 b). Western Guadalcanal is also prone to serious landslides, which is related to rainfall, slope, and soil characteristics. Landslides, too, add to the siltation of rivers and streams and changes in river dynamics. Debris combined with high velocity river flows generally cause scouring of foundations (abutment) around bridges and other crossing structures.

Such dynamics, although noted in the project documents, were not taken into account in the risk assessment used to inform the engineering design of culverts, bridges, etc (Cardno Acil 2009; Cardno Acil 2009 b). It is also noted that although parts of the road in the project area were very close to the coast, potential impact of sea-level rise, of storm surges were not factored in the risk reduction consideration, even though Solomon Island regularly experiences high winds, variabilities in the sea level due to ENSO events. These observations thus raise the question about what effect an integrated risk assessment would have had on the risk thresholds and the engineering standards adopted for the structures at each of the rivers and streams along the White River-Naro road, as well as costs and benefits and the choice of repair and road improvement options discussed below.

Choice of Risk Reduction Option

Engineering solution was the primary focus of risk reduction measures considered by the team, targeting different types of river crossing structures, such as causeways, fords and different types of bridges. The team had also decided not to undertake any significant realignment of the existing road, although the instability of the soft alluvial soils, which may necessitate realignment, was acknowledged. This adaptation measure was not explored because of concerns about land tenure issues and the impact of realignment on local communities. Risk reduction measures did though include some minor road realignments on land belonging to the same customary land owners, as well as drainage improvements, scour protection and river training. The team had, however, noted , but not pursued, the need to also pursue non-engineering climate adaptation strategies, such as better land management, including minimisation of the impacts of commercial logging practices, deforestation, and reforestation (Cardno Acil 2010 b).

Choice criteria

The choice of the risk reduction and climate change adaptation measure was based on predetermined minimum risk tolerance threshold assessed ' by serviceability [of the roads] in floods arising from high intensity storms' and 'as far as economically feasible' (p 11 Cardno Acil 2010).

For each of the physical structures a decision was made about the level of risk threshold that could be tolerated, taking into account the magnitude of rainfall events assessed using hydrological modelling discussed above (Q_2; Q_{10}; Q_{50}; Q_{100}); and modelled flow velocities, as well as expected flood levels for particular streams and rivers (see Table II.5, Cardno Acil 2009). Taking into account, the design of structures required to withstand different magnitudes of rainfall events, and acceptable threshold levels, three engineering project designs were considered, in addition to the 'do nothing option'. It seems that the cost of particular acceptable risk tolerance threshold was implicitly considered when deciding on which level of acceptable threshold would be used for the different structures along the White River-Nora road.

Photo 4.2 : Maladapted Causeway at Tomba Stream, which effectively dammed the stream, resulting in downstream erosion and structural failure during extreme flood events (source: Cardno Acil 2009).

Before flood (2008)

After flood

The four SIRIP2 designs were then subjected to cost benefit analysis (Table 4.10). Financial costs considered included the capital costs of the structures, operation costs and respective regular maintenance costs were assessed. Benefits of the road infrastructure repairs and improvement were assessed in terms of benefits of maintaining access, or the loss in earnings avoided by having structures under flood water, and or breaks in the river crossings preventing movement of vehicles and people. Such benefits were assessed using field traffic surveys; social survey of communities serviced by the road and the savings in repair of flood damaged structures (Cardno Acil 2010).

Based on the economic assessment, and using economic efficiency as criteria the ADB-SIG team chose the option B, where at least 1-in-2 year flow can be tolerated, and during 1 in 10 year events, some flooding of the structures may occur but vehicles with higher clearance could still pass through.

It is against this option B that the effects of projected changes in precipitation due to climate change structures were subsequently assessed.

Table 4.10 Costs and benefits of three options for addressing current weather related risks

	Do nothing	Option A	Option B	Option C
Repair and or improve	Emergency repairs only In the event of storms expect major damage and need for repairs Maintenance cost expected to increase annually by at least 5%	Restore to accommodate 2 year ARI flows.	Allow at least the 2 year ARI flow Expect some overtopping during 10 years ARI event, but expect to maintain connectivity for higher clearance vehicles.	Similar to Option B Offers a greater proportion of infrastructure designed to allow 100 year ARI flows
Capital + mobilisation Costs	Ruled out	$6,784000	$12,837,000	$18,856,000
Capital (Economic – excluding taxes)	$0	$6,286,000	$11,893,000	$17,470,000
Total Annual Cost (Economic)	$691,000	$941,644	$600,092	$553,630
Benefits (reduction in number of days downtime)	27.22	15.35	3.06	2.23
Benefits in terms of income not lost	(loss of SID 8.8 million)	SID 3.9 million	SID 7.83 million	SID 8.09 million
Economic Internal Rate of Return*		28.1%	30.8%	20.5%
* Over 20 year time horizon and in comparison with the 'do nothing' option				

Climate change assessment for climate proofing

Climate change consideration was not initially included in the project design considerations despite ADB's own conclusions about the need for climate proofing of infrastructure that has long lifespan (ADB 2005). This though was remedied in 2010, following another major flooding event. A preliminary climate change assessment was commissioned. Unlike the case of another SIRIP project at Makira where Hedley Modelling Group in UK was asked to do a detailed climate change scenario assessment, no climate change scenario modelling was specifically undertaken for the Western Guadalcanal road improvement project. The assessment relied on the Fourth Assessment Report scenarios for the South Pacific Region (discussed in Chapter2), and projected changes in precipitation, temperatures, cyclones and sea-level rise to draw general about climate change scenarios (Table 4.11). It is also unclear to what an extent the SIRIP 2 Western Guadalcanal project team sourced information from other Government departments, such as Water Resources Division, Forestry Department, Meteorology and Climate Change Unit. An interdepartmental committee was established, although it is difficult to confirm the level of active engagement and inputs that were forthcoming from the different departments during the project development process.

Table 4.11 Climate change scenario conclusions considered in the projected increases in climatic risks for the SIRIP project

Increase in mean precipitation and intensity; possibly including more intense rainfall in wet season (January to March), and leading to more intense surface flooding of road sections
Increases in maximum and mean tropical cyclone intensities
Sea-level rise of + 0.77 mm/year
Significant increases in the annual number of hot days and warm nights
Increases in the frequency of hot extremes
Source: Cardno Acil Ltd (2010 b).

Using these general projections, key assessment was then made by engineers about possible consequences for the designs of the different structures, proposed preventative measures and possible engineering adaptation solutions were identified (Table 4.12).

Table 4.12 Assessments about the effects of climate change on road infrastructure and potential adaptation responses

Hazard	Impact on the infrastructure	Preventative measures	Adaptation options
Sea Level rise and associated storm surges	• Some road sections may be submerged • Scouring of Bridge abutments	• -Use suitable materials and provide lateral protections • Raise the level of the road • Construct levy bank with drainage/ seawall • Realign road • additional longitudinal and	Engineering Options: • Re-enforcement of bridge abutments and repair of damaged ones are likely the most cost-effective solution. Natural infrastructure • Re-planting of mangroves, where physically possible, provide a cost

		transverse drainage systems • Protect levy bank with suitable mangroves	effective means to protect against wind and wave erosion.
Presence of large amounts of water	• Gully erosion • More severe floods • Water build-up • Overflow and mud /debris deposits making roads impassable and destroying bridges (i.e. wash out)	• Apply a safety factor in bridge and road level • Increase size and number of engineering structures (hydraulic structures, high bridges) • River training • Increase land cover in upper water catchment • Raise pavement and add drainage	Engineering Options: • Additional culverts and higher bridges • Regular maintenance Natural Infrastructure • Re-vegetation in upper catchment can be a community-based activity that provides income to villages affected by floods.
Source: Cardno Acil (2010 b).			

For each of the physical infrastructure, engineers then determined the types of actual adjustments that needed to be made to the initial choice of road repairs and improvements, using different levels of acceptable thresholds (Table 4.13). Thus for example, in the case of Sasa Ford (#13 (the Option B was designed to withstand 2 – year event (Q_2). Under climate change scenario this was increased in standard to withstand a 1 in 10 year precipitation and flooding event (or Q_{10}), thus 'climate proofing' that ford. In comparison, the Selwyn Ngautu Ford's design quality was increased from Q_2 to Q_{20}. In the case of structures that were already designed to withstand 1-in-10 year event, such as Sasa washout, no changes were required to cater for the projected increase in threshold tolerance.

Table 4.13 Some examples of the types of engineering design changes made in the light of projected climate change conclusion

No	Structure	Chg (kms)	Option B Proposed Restoration	Option B+CCA Proposed Restoration
1	Poha Bridge	7.8	New bridge 7 x 7m x 4.2m and raised approaches, scour protection, river training	New truss bridge 2x30m spans, 5.25m wide, demolish existing bridge, scour protection
3	Culvert	19.0	New Q2 causeway using 2m wide box cells	New Q10 causeway using 2m wide box cells
4	Tamboko Bridge	19.5	New bridge 10 x 7m x 4.2m and raised vented approaches, scour protection, river training	New bridge 10 x 7m x 4.2m perpendicular to flow and raised vented approaches, scour protection, river training extending upstream to village, debris catcher
9	Doma 2 Bridge	23.6	Replace eastern and western approach slabs with RC span and	New Q100 steel girder bridge using 21m span

			piled abutments, scour protection	
13	Sasa Ford	28.8	New Q2 causeway using 2m wide box cells	New Q10 causeway using 2m wide box cells
14	Sasa Bridge	30.2	New truss bridge 2x30m spans, 5.25m wide, demolish existing bridge, scour protection	New truss bridge 2x30m spans, 5.25m wide, demolish existing bridge, scour protection
15	Sasa Washout	30.3	New truss bridge 2x30m spans, 5.25m wide, scour protection, approach embankments, land bridge embankment, river training	New truss bridge 2x30m spans, 5.25m wide, scour protection, approach embankments, land bridge embankment, river training
20	Tameli / Chovuna Ford	36.2	New Q2 causeway using 2m wide box cells	New Q10 causeway using 2m wide box cells
24	Konavua Bridge	46.0	Reinstate approach slabs, scour protection	Reinstate approach slabs, scour protection
25	Selwyn Ngautu Ford	49.0	New Q2 causeway using 2m wide box cells, sealed approaches	New Q20 causeway using 2m wide box cells, sealed approaches
Source: Cardno Acil (2009).				

Based on the proposed engineering solutions under assumed climate change scenarios and qualitative assessment of projected impacts, further economic cost benefit analysis was done for the indicative climate change adaptation. Thus economic net benefit of the CCA changes was then compared with the net benefit of the chosen risk reduction measure for addressing current disaster risk engineering solution. As the benefit cost ratio was greater than 1 and the economic internal rate of return was estimated to be 12.8 (that is greater than 12% considered being an acceptable threshold); the decision to proceed with the changes in the engineering solutions was made (Table 4.14).

Table 4.14 Economic cost benefit analysis of CCA options considered

Present value of Costs Option B	$16.623.000
Present value of Costs of Option B+CCA	$20,089,000
Incremental costs of CCA (over Option B)	$3,466,000
Incremental Benefit from CCA (PV of Benefits)	$3,731,000
NPV	$265,000
Benefit cost ration	1.1
Source: Cardno Acil (2010 b).	

Key lessons from the ADB-SIF SIRIP2 Case Study

This review of ADB-SIG's climate proofing project implemented by ADB in the Solomon Islands in partnership with the Ministry of Infrastructure and Development highlights several issues of relevance when considering social and economic assessment based climate change adaption decisions.

Climate proofing

1. Climate proofing of the SIRP 2 road repairs and improvement project, White River to Nora Hills was not considered in the original design, although subsequent consideration of climate change demonstrates that a proactive adaptation strategy is more cost efficient that retrofitting. This is consistent with the assessment done by ADB for Kosrae, for example (ADB 2005).

2. Although the ADB-SIG SIRP 2 project was aimed at 'climate proofing' the repair and improvement of the roads in the North-Western Guadalcanal, and systematically followed key steps involved in risk management cycle, the focus was on rain induced flooding risks and its effects on crossing structures designed for various rivers and streams. Other geophysical systems dynamics and their impact on river flow, flooding and hazards was not explicitly considered.

Integrated risk assessment

3. An integrated climate risk (hazard & vulnerability) assessment is relevant when weather and climate conditions generate multiple hazards, as is the case in the Guadalcanal SIRIP2 project area. Current weather and projected climate change risks in the Guadalcanal floods plain are a product of the weather and climate conditions and the sensitivity of the physical / ecological system in the Guadalcanal flood plains that drives the scale and scope of local hazards and vulnerability (as well as the sensitivity of the local communities, and assets). Such an integrated assessment is required to not only identify current and projected risks, but also to identify and assess alternative risk reduction measures, particularly where local physical/ ecological systems are particularly sensitive to changes in weather and climate conditions.

Impacts first or vulnerability first approach

4. The robustness of science or 'impact first' based risk assessment implicitly adopted in the SIRIP2 project to address current weather related risks depends on the underlying data sourced and used.

   Where data and models are borrowed from other countries, the robustness of the risk assessments could be improved by triangulating those models against known scientific information in published and or grey literature produced under other development projects. Where possible, key modelling parameters could be adjusting by comparing information from other sources with the available data. This could have been easily done, as there are many sources of data information that could have been sourced from within the government and from modelling results from other detailed hydrological assessments in the country; although it is recognised that information system needs considerable strengthening. A national system of climate information services, linked to georeferenced data system, could encourage access to, and use of relevant data and information maintained by different government agencies and ministries to inform climate change adaptation decisions.

5. Given the level of uncertainties associated with climate change, not only because of difficulties in downscaling global climate models (as discussed in Chapter 2), but also because of uncertainties associated with limited scientific understanding about dynamics of the local physical/ ecological systems, sensitivity analysis could have provided better information base to support key decisions.

6. In the presence of limited empirical data and scientific understanding, translating the effects of the climate change on hazards and vulnerability conditions can be difficult. In addition, it can be equally challenging to identify relevant solutions to address the respective vulnerability conditions. All that may be possible is some qualitative assessment, and making some decisions based on expert knowledge and experiences, using tools such as multi criteria analysis.

7. For the Solomon Islands, and Pacific island countries in general, a systematic application of the hybrid 'impacts first and vulnerability first' assessment approach based risk assessment (Figures 3.3), can help identify what can be empirically assessed and qualitatively described. Then using the cost benefit analysis of climate change adaptation illustrated in Figure 3.5 can help identify and compare costs and benefits of adaptation measures, and to make informed choice using multiple criteria.

5. Challenges of Undertaking Economic Analysis of CCA in the Pacific: Past project and planning level assessments

Climate change risks demand multi-pronged adaptation responses, supported by economic and social assessments. The Pacific island countries have undertaken, to varying degree of detail, such assessments at the national and sectoral planning level, as well as at the project level.

National and sectoral mainstreaming

With the assistance of SOPAC (SPC) and SPREP and development partners, such as AusAID, ADB, UNDP and the World Bank, much attention in relation to disaster risk management and climate change adaptation has been on supporting countries to produce their national action plans for DRM and CCA guided by respectively, the Pacific Disaster Risk Reduction and Disaster Management Framework for Action, 2005-2015, and Pacific Islands Framework of Action on Climate Change (PIFACC) and National Communications Guidelines produced by UNFCCC.

These two streams of disaster risk management have generally been pursued in parallel by international agencies, regional CROP agencies and countries, although substantial efforts have been made in the last 1-2 years to streamline and link activities more strategically. In 2011, the Pacific Disaster Platform agreed on a road map for a joint CCA/DRM strategy and will be presented to the Leaders for consideration.

At the country level, there is arguably little coordination or integration of the two approaches, neither between institutions supporting DRM and CCA, nor during the implementation of policies, plans, programs and activities, let alone in the approaches and tools used in respective decision-making processes (Hay 2009a; Hay 2009b; Gero, Méheux et al. 2011). This is despite both instruments being based on essentially the same risk management framework and are guided by similar risk management principles (Table 5.1). There are certainly opportunities to enhance integration of CCA and DRM in Pacific Island Countries through improved coordination of activities at the regional and national levels, not to mention through integration at the international level as well.

In this respect, Pacific island countries have arguably taken the lead in moving towards integrating DRR and CCA measures, adopting slightly different approaches (Hay 2009 b). Tonga and RMI approached this, with guidance and support from SPREP and the SOPAC Division of SPC, by producing a joint national action plan (JNAP) for climate change and disaster risk management; countries such as Palau and the Cook Islands currently developing theirs. At the same time, the Federated States of Micronesia have attempted integrating disaster risk reduction and climate change adaptation effort by using their common government agency platform under which both the instruments are implemented. Others such as SI and Vanuatu are considering whether or how to integrate climate change considerations to the development of their DRM NAPs.

Table 5.1: RFA & PIFACC Guiding Principles and process outcomes

***Regional Framework for Action on DRM*[1]**	***Regional Framework for Climate Change*[2]**	***Enabling environment and process outcomes***
Governance: Organizational, institutional, policy and decision-making frameworks	Governance and decision-making	Good governance and informed decision-making
	Partnerships and cooperation	Effective leadership and coordination amongst government and regional agencies, and development partners to support knowledge based decisions and to create synergistic outcomes
Knowledge, information, public awareness and education	Education, training and awareness	Information system integrating science, social science based and experiential and traditional knowledge
		Knowledge-based decision making processes supported by analytical tools and methodologies
		Human and institutional capacity to make knowledge based objective decisions reflecting key development objective
Analysis and evaluation of hazards, vulnerability and elements at risk	Improving our understanding of climate change	Robust assessments of climate and other hazards, vulnerability and uncertainties, as well as disaster impact and adaptation response assessments
Planning for effective preparedness, response and recovery		Mainstreaming risk reduction (& adaptation) into policies, plans, legislations and other instruments
		Well organised and integrated policy, planning and budgetary processes
		Coordinated national and sectoral risk management policies and plans, and responses targeting priority climatic risks
		Well-designed priority adaptation projects/ programs aimed at disaster risk reduction and disaster management implemented effectively
Effective, integrated and people-focussed early warning systems		Effective and integrated early warning system and people friendly communication strategies and messages
Reduction of underlying risk factor	Implementing adaptation measures	Reduction of underlying risk factors through a proactive and reactive adaptation and other measures across different scales
		Community and private sector based adaptation activities for private risk reduction

At the implementation level Pacific island countries have begun to develop sector plans to integrate climate change considerations under the GEF funded Pacific Adaptation to Climate Change (PACC) project (Table 5.2). For example, Solomon Islands and Palau are both working on developing national climate change policy for their agricultural sectors (PACC Mid-Term Review, Port Vila, August 1-5, 2011). On the other hand, Tuvalu and Nauru are developing their national water policies/ plans under their PACC projects.

Table 5.2 Example of CCA measures identified for development as part of the GEF funded PACC projects

Countries	Target Sector	Policy	Sector Plan	Adaptation Activity
Fiji	Food security (Infrastructure)		Guidelines for climate proofing of drains and drainage	Drains and drainage network redesign with respect to increased rainfall and SLR Revised Drainage Act
Cook Islands	Infrastructure	Proposed RM-CCA-RE policy		
Nauru	Water	Nauru Water, Sanitation and Hygiene Policy reflecting CC considerations	Drought Management Strategy Plan under the Disaster Risk Framework Water, Climate Change Action Plan	Salt water reticulated system; solar water purifiers Rainwater harvesting catchments
Tonga	Water	National Water Policy	National CCA Action Plan for the Water Sector	Water supply
Tuvalu	Water	National Climate Change Policy	National Water Policy revised to include CC considerations	Water harvesting and storage
Source: SPREP (2011).				

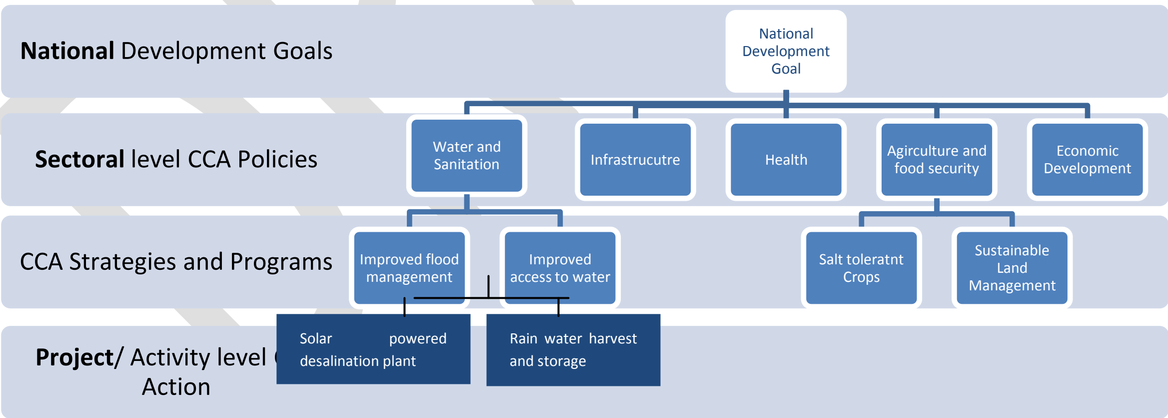
Adaptation priorities

At the national level, adaptation priorities were initially identified during the Initial National Communication reporting process, guided by the guidelines provided by the UNFCCC secretariat. In order to inform these adaptation priorities, countries used past hazard data in addition to assessment of broad aggregate level social and economic information on their current disaster risks. Future hazard conditions were drawn from available global level climate change scenario information together with any regional or national level information available from NIWA, CSIRO or SIMCLIM groups. Projected impacts were assessed and identified by special technical working groups established as part of the process used to prepare National Communication reports to UNFCCC (such as Vulnerability and Adaptation Thematic Working Group in Nauru).

Sectoral level impact assessments usually had been qualitative in nature, with technical working groups drawing on sector status reports prepared for the adaptation planning process. Prioritisation of key sectors to target for adaptation effort has implicitly followed a CBA process outlined above. In some countries, priority sectors were identified using expert judgement of the technical working groups. For example, members of technical working groups in countries such as Vanuatu ((Vanuatu Government- National Advisory Committee on Climate Change 2007), and Nauru (Nauru Department of Commerce Industry and Environment (CIE) 2010 (draft)), used specific weighted scores for sectors based on available quantitative information about hazards, social and economic conditions, expected benefits (or avoided costs) of adaptation, and multi-criteria analysis to arrive at the nationally important sectors under their national CC Adaptation Framework. However, such as systematic assessment, scoring and multi-criteria analysis is not evident in the identification and implementation of CCA projects on the ground, as discussed below.

If such a systematic approach is adopted, regardless of the entry points and the sequence of their development, one could expect to find a direct relationship between, for example, national development goal, sectoral plans and policies and specific adaptation activities on the ground (Figure 5.1). For example, the SI Medium Term Development Strategy includes an objective ‘to ensure sustainable utilization and conservation of natural resources, protection of the environment and successful adaptation to climate change’. It also notes the implementation of strategies to ensure effective mitigation and adaptation to climate change’ (Solomon Islands Government 2008).

Figure 5.1 Climate Change Adaptation Measures – Relationship between at National Development Goals and Sectoral level CCA measures- Policies, Strategies and Actions



However, the relationship between goals, sector objective and activities is not always clear. In Nauru, for example, a link between national development goal and the sector objectives can be found, but not necessarily between the sector priorities and on-the ground projects implemented under the PACC project (Table 5.3). Similarly, the National Transport Plan (NTP) in the Solomon Islands clearly articulates the need for climate proofing of infrastructure as highlighted in their NAPA. But there are no specific strategies aimed at operationalising this (see detailed case study on SI and climate proofing), and it notes that *that currently engineers are designing ridges and wharves* *to withstand extreme events caused by climate after past experiences and... there is no clear direction of taking future climate change impacts into account (Government of Solomon Islands 2010).*

Table 5.3 Nature of national development goal, sectoral plan and priorities and on the ground project/ activities identified by Nauru

Output of CC mainstreaming	Climate Change Adaptation Measure
NSDS Goal in relation to Water & Sanitation	Provide a reliable, safe, affordable, secure and sustainable water supply to meet socio-economic development nee
Water Sector Plan and priority sector strategies	National Water Plan 2001 priority actions identified included: • establishment of a secondary desalination plant, extraction from the fresh surface layer from the groundwater lens (if possible), • installation of groundwater monitoring wells and clear delineation of the extent of underground resources so as not to risk over pumping.
Examples of an Adaptation Activity	Pacific Adaptation to Climate Change Project (PACC): • solar powered desalination a the household level, • saltwater reticulated system; and • water harvest and storage.

Source: Nauru Department of Commerce Industry and Environment (2010 (draft)) ; SPREP (2011)

Even at the national and sector development plan levels, this is not always the case in the region. For example, in the Cook Islands the National Development Goal 6 is for a safe and resilient community. However, with a few exceptions, little in the NSDP relates specifically to enhancing community resilience to natural disasters and climate change (Hay 2009a). Similarly while the NSDP in the Cook Islands call for implementation of priority actions related to climate change that are relevant to land, coastal zone, freshwater and marine resources, many adaption projects already being implemented, including PACC; focus on water, waste and sanitation and infrastructure (Hay 2009a). Similarly, Fiji's Strategic Development Plan (SDP) 2007-2011 urged the mainstreaming of disaster risk reduction into sectoral development plans, policies and programs, noting the importance of this for sustainable development and community resilience. No particular strategy is included in the Sustainable Economic and Empowerment Development Strategy (SEEDS) 2008-2010, adopted in 2007, although the Government of Fiji proposed integrating disaster risk reduction into political decisions, stating that Government efforts are underpinned by a "risk management approach" (Hay 2009 a). Fiji's climate change policy approved by Cabinet in 2007, and used an elaborated framework and provided policy statements and strategies; it has not been implemented in a cohesive manner.

In Vanuatu, despite recognising the need 'to build climate change issues into national development plans', its Priorities and Action Agenda for Vanuatu, 2006-2015, does not cover the issue of climate change adaption in any other area of the document, except passing reference to it in the section on infrastructure. Nor is the issue of disaster risk management given the treatment that it did in the Supplementary PAA attached to their previous PAA, 2005-2007 (King 2010 (draft)).

In some cases, as illustrated in the detailed case studies discussed in Chapter 4, there is little evidence that context-specific and systematic analysis, even if qualitative, generally informed the identification of specific activities, and or project design. Many a time, it seems that projects were apriori identified or selected based on 'risk perception' and at times, at times reflecting the interests of the development partners and or implementing agencies.

There also seems to be a disconnect between CCA plans and policies and the identification and implementation of 'on the ground' projects. Hay notes that a key feature of the locally-focussed on the ground CCA initiatives is that they are largely occurring in a policy vacuum with little budget support (Hay 2009a). He argues that they often are driven by the needs of the local communities with support from bi- and multilateral support without being an integral part of national policies, planning and budgetary processes. Because of the weak or missing linkages at the policy level, and capacity constraints, governments are also missing out on opportunities to ensure that the national-level enabling environment is supportive of the adaptation efforts at community level. The effectiveness of CCA measures could be improved in the priority sectors if greater attention were paid to mainstreaming climate change considerations into sector policies and strategies (Wickham, Kinch et al. 2009).

Project level assessment

Evidence of detailed project level social and economic assessment of CCA initiatives in the Pacific is limited. Earlier between late 1990s and early 2000, economic and social assessments were undertaken as part of research projects not directly linked to specific CCA decision making. They focussed on assessing the costs of climate change using a variety of approaches and based different levels of empirical data (Lal, Wickham et al. 2009). The SOPAC Division of SPC has carried out a variety of CBA of interventions relating to water and disaster risk management that could be seen as potential climate change adaptation projects; although not classified as adaptation to climate change initiatives per se (see e.g. Woodruff 2008; Holland 2009; Gerber 2010). Most of these assessments were ex-ante CBAs after the specific project decision had been made but before the project activity was completed.

Economic assessments of actual climate change adaptation are few. Implicitly adopting, 'impacts' first' approach, the majority of them based on simplified economic models and or using several assumptions due to limited data (Table 5.4). Most recently, the World Bank (World Bank 2010a), adopted macroeconomic assessment to estimates economic costs of climate change (i.e. without adaptation) in Samoa. They used available climate change scenarios information and assumed changes in the storm intensity and frequency, expected impacts of the different sectors, such as coastal zone, water, tourism and agriculture, giving an economic costs of about \$104–\$212 million by 2050; this is equivalent to 0.6–1.3 percent of the present value of GDP over the same period. Using various adaptation measures outlined in Samoa's NAPA, the World Bank also emphasised the nature of economy-wide economic benefits of CCA. Similarly, ADB used a 'with and without' CBA analysis to determine the net present values associated with proactive climate proofing of roads as compared with retrofitting to reflect projected climate change conditions in Kosrae (ADB 2005). However, such 'impacts first' based assessments were not integral to any policy decisions in country; this is though not unique to the Pacific. Global experiences also suggest that modelling based impact first assessment approaches have not always yielded useful results for the purpose of adaptation due to constraints associated with uncertainties of climate and socio-economic scenarios, ‘mismatch’ of scales between the scales at which scenarios are readily available and that at which adaptation policy is formulated (see various references in Burton, Huq et al. 2002).

Table 5.4 Examples of different categories of economic assessments undertaken in the Pacific

	Examples
Quantitative economic estimates based on empirical climate change scenarios and projected sectoral/ economy-wide impacts	World Bank 2000; Shorten et al 2003; (ADB 2005; The World Bank 2010); Fiji’s First Communication Report
Qualitative economic impact assessment based on context specific climate change scenarios and limited sectoral impact assessment	Nunn et al 1994; Koshy 2007
Qualitative comments on the nature of CC impacts on economic activity (community vulnerability assessments) using projected IPCC CC scenarios, and general country specific environmental, social and economic characteristics	Hay and McGregor1994; Sem and Underhill 1994; Reti 2008; Hay et al 2003; Carruthers and Bishop 2003) (Vanuatu Government- National Advisory Committee on Climate Change 2007)
Source: Adapted from Lal, Wickham et al (2009).	

Generally speaking, economic and social assessments of CCA do not seem to be well integrated into climate risk management processes across all levels of decision-making in the Pacific. Many of the externally funded community-based adaptation projects are implemented by community-based organisations, and local non-government organisations (NGOs). Usually there seems to be no systematic institutional arrangement for engagement with local or national governments and engagement with communities is very ad hoc and ephemeral (Hay 2009a). There may be benefits from ensuring that adaptation is designed to ensure coordination and accountability of conservation NGOs working at regional and/or national levels, and to secure the sustainability of such benefits once the projects are completed (Siwatibau and Lees 2007).

Of the case studies considered in this report, the rationale for the adaptation measures selected was not always clear. Review of some key regional climate change adaptation projects in the region suggest that specific project activities were not necessarily selected on the basis of any systematic risk analysis, or risk management assessment and prioritisation. Nevertheless, some effort has been made to undertake community vulnerability and adaptation assessment (V&A) at the project level (Table 5.5), such as in the Canadian funded CBDMPIC (community building for the development of adaptation measures in the Pacific Island) project.

Table 5.5 Examples of the types of project based vulnerability assessment tools used in the Pacific

Tools	Used By
Community Vulnerability and Adaptation Assessment (CV & A) tool kit	SPREP in Vanuatu, Cook Islands, Samoa, Fiji through the CBDAMPIC project
Climate Witness Tool kit	WWF – Pacific Programme
NAPA Guide	Solomon Islands, Vanuatu, Kiribati, Tuvalu and Samoa
Vulnerability Capacity Assessment VCA)	Solomon Islands Red Cross
National Climate Risk Profiling	Samoa with the assistance of World Bank
Source: (Wickham, Kinch et al. 2009)	

Current projects under the UNDP-GEF funded Pacific Adaptation to Climate Change Adaptation projects in 14 countries have also undertaken modified V&A reflected in the socioeconomic analysis (SEA); SEA is essentially an extension of the earlier community based V&A assessment adopted in the CDMPAC project, to guide the project teams through the process of risk assessment, as well as expected benefits of the proposed adaptation measures.

As illustrated above with the CBDMPC project in Vanuatu and PACC project in Tuvalu, such assessments were not linked to the identification of adaptation measures or in the selection specific adaptation strategies. In the case of the PACC project, it seems (from the project documents, and the mid-term review presentation of the PACC projects) that the CCA measures were in some cases *a priori* decided upon based on the sectors of particular concerns identified by the countries in their National Communications to UNFCCC; the National Adaptation Programmes of Action (NAPAs); other policy documents; and the interests of the development partners and or implementing agencies. Although effort was made to confirm the validity of this decision at demonstration site, Lofeagai, during the CV&A (SEA & CV&A 2011 (October draft).

Institutionally, project specific stakeholder based committees were established and who then engaged in the vulnerability assessment. Such decisions are made in a vacuum without any institutional mechanism that ensures that scientific and other information is shared across governments and civil societies and the approaches and tools integrated into the national or community-based decision-making level; often different V&A tools used in the same country, and even in the same project.

Amongst the key impediments to enhance systematic vulnerability assessment includes (Wickham, Kinch et al. 2009):

- poor baseline information;
- little capacity to manage knowledge
- CROP and donor agencies promoting separate information tools, approaches and networks instead of integrated system; and
- Absence of strategies for knowledge management, and[processes for] making knowledge based decisions.

In an environment of uncertainty and limited information, international literature suggests that effective adaptation measures should be robust and flexible; an adaptation is considered to be robust when the adaptation option has the ability to perform adequately across a wide variety of possible futures. It is flexible when it has the ‘ability to be adjusted to new information or circumstances in the future’ (Ranger, Milner et al. 2010).

6. Strengthening CCA in the Pacific: a social and economic assessment based decision-making process

Policy and project cycle-based decision-making process can help systematically assess risks and risk reduction benefits by identifying adaptation measures that address the desired goals across national and sectoral policy and planning levels and at the project level. Several different tools and approaches are available to support climate risk management (see various tools identified in (OECD 2009; USAID 2009; Hamill and Tanner 2010; Olhoff and Schaer 2010). Social and economic assessments are integral aspect of these tools and approaches for making informed decisions about climate change adaptation across all levels of decision-making, even if not all benefits and costs may be quantifiable.

Chapters 4 and 5 provided an overview of the analytical and decision-making frameworks generally used internationally for climate risk management, and of recent experience in the use of climate risk management framework in the Pacific. Countries can adopt many different adaptation measures but robust and effective actions would no doubt be influenced by resource constraints as well as available information.

These Chapters highlighted key challenges in the use 'impact first' or 'vulnerability first' approaches in the Pacific, and in the use of CBA analytical tool in selecting CCA activities. As discussed, the difference between 'impacts first' and vulnerability first' approaches is one of at what stage climatic risk is explicitly considered and the degree to which detailed quantitative estimation of costs and benefits are relied upon to make the decisions. 'Impact first' approach is data hungry, and largely relies scientific knowledge of past experiences as well as scientific projections of future climatic scenarios and expected impacts. 'Vulnerability first' approach is less data hungry, and more reliant on stakeholders based Delphi approach to decision –making, including multi-criteria analysis, within the climate risk management context. Regular reviews and 'learning by doing' and adapting to new information over time is an integral part of climate risk management.

Although recognising the importance of making informed decisions based on best available scientific and traditional knowledge, Pacific island countries are often faced with limited empirical data and information. In such a situation PICS could explicitly adopt 'vulnerability first' approach to risk management supported by detailed climate and risk analysis where possible. They could build on the V&A assessment approach used in regional projects in the Pacific and adopt a seven-step process outlined in Table 6.1, combining the concepts captured in the 'vulnerability first' approach and risk management framework, together with social and economic assessment of risks and adaptation measures.

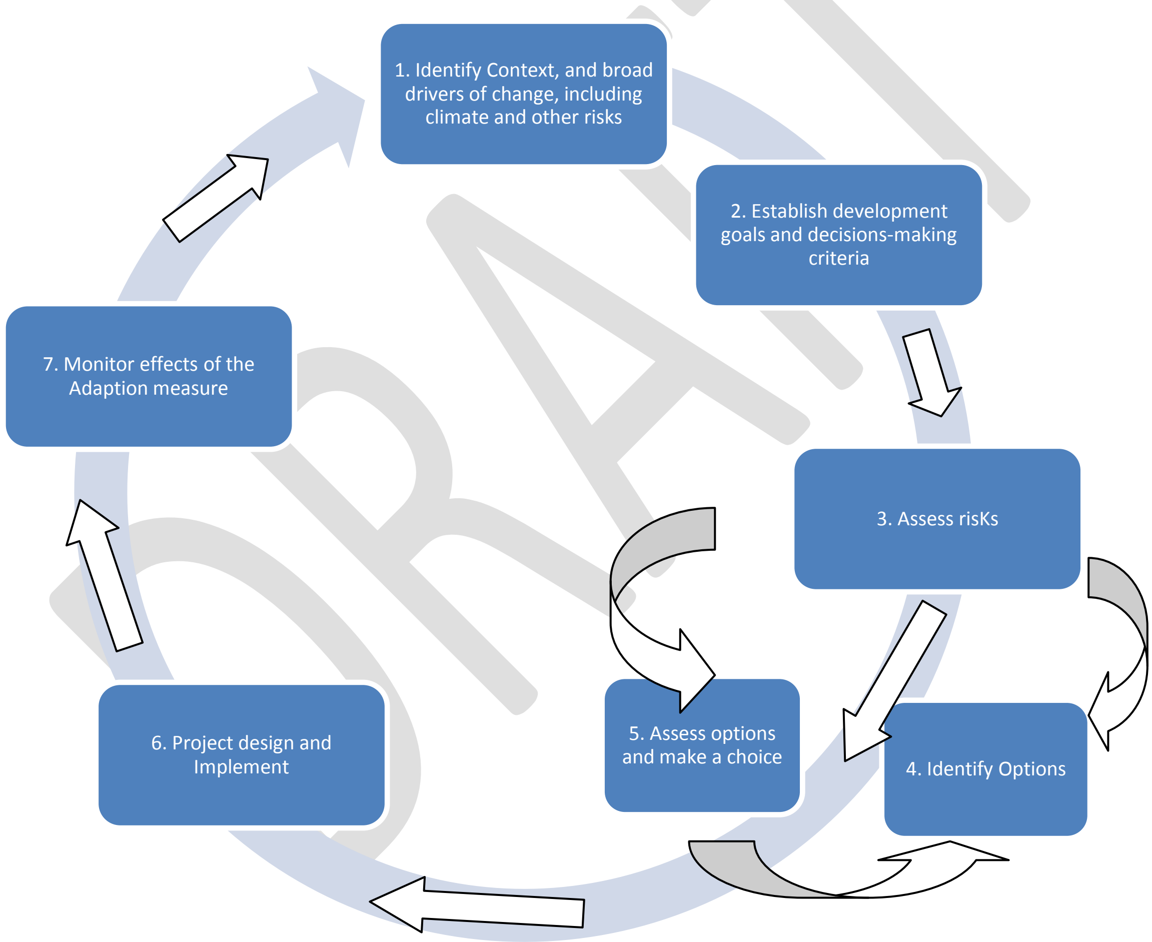
Table 6.1 A seven-step decision-making process for the Pacific

Step	Activity	Output/outcome
1	Understand the social, economic and environmental context of communities, broad drivers of change, including climate and other risks – situation analysis	Baseline data to identify parameters for adaptation monitoring Baseline data to assess success/progress of adaptation measure
2	Establish development goals and specific decisions-making criteria	Clarity in how the adaptation measure directly contributes to national priorities for economic, social and environmental goals
3	Assess current risk of climate change (and other drivers) – assessment of hazards and vulnerability	Qualitative and or quantitative assessment of risk to enable estimation of the benefits of the adaptation measure
4	Identify different adaptation measures, taking into account the urgency of their implementation, depending on the dynamics of the economic sectors and the dynamic of the climate change impacts	Identify alternative adaptation measures that address current risks and projected risks, considering the dynamics of the underlying economic systems and the dynamics of climate change impacts
5	Evaluate alternative adaptation options using cost benefit analytical framework (process or tool) using one of three – tiered assessment approach	Step wise assessment of each adaptation option against the pre-identified criteria (from step 2) Identification of baseline needs, data gaps, before undertaking detailed CBA where appropriate Selection of a preferred adaption option
6	Conduct a detailed design and implementation plan, including identification of indicators of the effectiveness of the measure, time horizon; and implement	A feasible and cost effective design
7	Monitor and evaluate the adaptation measure, and adjust throughout implementation in the light of changes in socioeconomic, technological conditions as well as new scientific information.	Learning by doing Adjustments over time as new information becomes available

In addition, acknowledging that quantitative social and economic assessment of adaptation measures is not always possible, particularly due to data and capacity constraints, the three-tiered assessment approach advocated by Ranger et al. (2010) is particularly relevant to the PICS. It is possible that a decision-maker may progressively move from Tier 1 to Tier 2 to Tier 3 level of quantification if adaptation and management response warranted the detailed assessment.

As a minimum, broad brush risk screening is likely to be more suitable at the national planning level, where key policy decisions need to be made in the context of national development, development of national action plan for DRM, NAPA and the joint NAPs (see Figure 5.1). In such contexts, aggregate level baseline information could be sufficient to identify the broad scale and direction of risks and adaptation measures required to address climate risks (steps 3, 4, 5 in Figure 6.1). At this level, governments are typically faced with making decisions that broadly balance their key economic, social and development goals, and broad assessment based adaptation paths could suffice; a risk screening approach was used successfully in the mainstreaming at national planning and budgetary level, in Nauru, for example, as discussed above. The adaptation options may be selected based on the priority pathways selected, as summarised in Figure 3.8 above.

Figure 6.1 Decision-making process for adaptation based on 'vulnerability first' approach at policy, plan or project levels - recognising uncertainties and data constraints



Source: Adapted from Willows and Connell (2003); and Ranger, Milner et al (2010).

A more detailed level of assessment would generally be required at the sector level, when identifying specific sectors to target as well as when developing detailed sectoral level strategies and programs for action (again such an analysis will be undertaken in steps 3,4,5 but at the sectoral level) This level of assessment will result in both quantitative and qualitative information and would rely on expert judgements, or event a more systematic multi-criteria analysis to inform choices, such as in the case of Nauru where priority sectors were identified using quantitative, qualitative information and expert judgments.

Quantitative CBA of adaptation options is generally useful where choice between adaption options will be improved by detailed quantitative assessment of risks and uncertainties, particularly where the geographic scope and scale of CCA measure is large and or has a long shelf life. Once again, in the case of project development, such a detailed context specific analysis ideally would occur during the steps 3, 4, 5 illustrated in Figure 6.1.

Concluding remarks

For the Pacific SIDS, the adoption of a climate risk management framework supported by best available scientific, traditional and experiential knowledge would help strengthen systematic analysis of changes in climatic risks, and offers benefits to identifying, selecting and assessing adaptation measures. This is despite its limited explicit use so far in the region.

'Impact First" or 'Vulnerability first' approach

In the Pacific 'impact first' approach alone to risk management decision-making may not be practical because of difficulties undertaking detailed probabilistic risk assessment. Probabilistic risk assessment is difficult in the Pacific largely because of the challenges in determining loss frequency distribution in the presence of limited geo-referenced and detailed baseline information about current and future hazards and effects, and socioeconomic data required for estimating climate impacts and benefits of adaptation measures. The Pacific though is not alone in facing such difficulties. It is also noted that even in the more developed country context, where better empirical baseline data is available, practical experience suggests that 'impacts first' approach is questionable (Ranger, Millner et al. 2010) because the process is subject to ballooning (or magnification) of uncertainties and the range of impacts and their implied adaptation responses become impractical (Dessai, Lu et al. 2005; Wilby and Dessai 2010).

Probabilistic or deterministic CBA

Probabilistic cost benefit analysis of adaptation measures is difficult in the Pacific as locally relevant climate projections with associated likelihood estimates is almost non-existent. Instead deterministic cost benefit analysis, including cost effectiveness analysis, together with sensitivity analysis could provide a second best approach in informing adaptation choices, even though its use in the Pacific to select adaptation activities and projects has been limited to development partners. CBA may not provide efficient choices when there is limited scientific understanding of the impacts of climate change, as well as the presence of uncertainties about the effects of future climatic events, the difficulties in estimating all benefits and costs in monetary terms, differences in opinion about the appropriate discount rates to use, and other data restrictions. However, efficiency may not always be the sole criteria for decision-making under uncertainties, and issues such as equity, no-regrets and flexibility are difficult to capture.

Despite such complexities, the use of CBA as a process could still be useful in helping to systematically organise, assess, and present and compare costs and benefits of different option. The application of CBA as a process can still help provide quantitative and qualitative information, including non-economic ones, on which to base ones choice, using techniques such as multi criteria analysis (with or without explicit use of scoring and weightings).

Vulnerability and adaptation (V&A) assessment tool commonly used in many 'on the ground' projects in the Pacific could provide a good starting point for a more systematic approach to identifying adaptation measures at the national and sectoral policy and project levels. Assessment from the perspective of households and their wellbeing would also require assessment of their vulnerabilities and for which sustainable livelihood framework could be useful to structure the assessment and synthesise the information for input into the CBA process.

In addition to the systematic analysis of risks, and risk adaptation options and making informed choices, greater attention to specific project design is also critical if the adaption measure is to achieve its desired outcome. Observations on many of the current CCA activities in the Pacific suggest opportunities to improve initial project design, including the use of local knowledge, to ameliorate the efficient use of project resources. The World Bank, too, noted in the context of disaster risk management that a robust project design is often more effective and efficient (World Bank 2009)

Adaptation measures

Adaptation measures would ideally cover a spectrum of responses focusing on current and future risks. These may range from measures that address underlying drivers of vulnerability, reduce hazards and exposure to hazards, prepare and respond to residual risks, as well as directly respond to specific long term climate futures.

Countries may choose different entry point (s) (national or sectoral policy, plans, programs and/ or project/ activity level) for addressing challenges of increased risks due to variability and extreme climatic conditions. However, countries with an enabling environment where there is a direct relationship between national development goals, plans and strategies, sectoral level programs and strategies and individual projects are likely to achieve effective, synergistic, robust and flexible outcomes. Successful and sustainable adaptation is also more likely to be achieved when decision-making processes across all levels are based on systematic identification and assessment of risks, and adaptive responses.

Decisions at all levels – national policy and planning, sectoral planning and programming, and on the ground projects – could be made on the basis of cascading set of quantitative, semi qualitative & qualitative, and qualitative information involving key stakeholders with scientific and traditional knowledge, and risk management experiences adopting a systematic risk management framework, and recognising the uncertainties in projected climate conditions and future impacts. The degree of detailed empirical assessments required is expected to increase as one move from developing national policy, sectoral policy and program, to specific project level decisions.

Effective and sustainable adaptation to climate change demands flexible and sound decision-making process where climate and disaster risks are an integral part of national development processes. Given the reality of incomplete information, and uncertainties about climate futures, as new information becomes available, and lessons are learnt from past decisions, these would also need to be fed back into decision-making process, encouraging new or modified adaptation measures.

Flexible and adaptive decision-making process would become critical as future climate risks may have little semblance with the past disaster experiences.

Climate information services

Countries could benefit from a coordinated system of climate services that is responsive to user needs, and involves national and regional expertise providing sound knwoeldge base analytical advice, bringing together climate science, economic and social sciences as well as traditional and experiential knowledge.

Latest modelling efforts by BOM and CSIRO provides a greater confidence in some aspects of future projections of climate variability, trends in air and sea temperatures, rainfall, tropical cyclones and other variables. Such an effort without doubt needs to be further enhanced such that country specific projections of climate conditions and hazards can be enhanced.

Globally, while emphasis has generally been placed on climate change science and fine-tuning climate projections, it is equally important to invest in national level understanding of the dynamics of interactions between climate and economic and social systems, and impacts of climatic variability and extremes on key sectors that underpin national economy and social well being.

In the region, attention is needed to improve baseline information on current and future risks, including hazard and vulnerable analysis, and spatially disaggregated social and economic information, and capacity to use such information to inform policy and project choices. It is only when these two bodies of knowledge come together with traditional knowledge and experiences, that governments and communities can make informed choices in response to current and future weather and climate projections. This is consistent with the conclusion made by the World Bank (World Bank 2009), which noted that 'more importance should be placed on establishing and using fully functional and comprehensive information bases, including their use in building understanding of the priority issues and appropriate responses" (p 31).

A linked regional-national climate service could be useful, recognising that in-country capacity is often limited. Such a climatic services, as noted by (US National Academy of Sciences (Panel on Informing Effective Decision and Actions Related to Climate Change) 2010), would ideally have rigorous scientific underpinnings (in climate research, vulnerability analysis, decision support, and communication), performs operational activities (timely delivery of relevant information and assessments), can be used for ongoing evaluation of climate change and climate decisions, and has an easily accessible information portal that facilitates coordination of data among agencies and a dialogue between information users and providers. Such a service would also include strengthening of national level decision-making process and other enabling environments, that promote knowledge based decision-making and actions, as well as technical capacity to make informed decisions.

Ultimately, an effective adaptation to climate change requires a national system of climate risk management supported by the best available scientific and traditional knowledge, and institutional capacity to make informed decisions, and adapt as new knowledge and information becomes available. That is, if effective, efficient, robust and flexible adaptation outcome is to be achieved.

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