Review of Economic and Livelihood Impact Assessments of, and Adaptation to, Climate Change in Melanesia

Padma Narsey Lal, Jeff Kinch and Frank Wickham

SPREP
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Secretariat of the Pacific Regional Environment Programme
PO Box 240, Apia, Samoa
Tel: +685 21929
Fax: +685 20231
Email: sprep@sprep.org
http://www.sprep.org/

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Ricardo Morris/Freesoul Media, Suva

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Acronyms

ADB	Asian Development Bank
AR4	IPCC Assessment Report 4
AusAID	Australian Assistance for International Development
CBDAMPIC	Capacity Building for the Development of Adaptation Measures in Pacific Island Countries
CIDA	Canadian International Development Agency
DWFNs	Distant water fishing nations
DRR&DM	Disaster risk reduction and disaster management
EEZ	Exclusive economic zone
EMDAT	International Emergency Disasters Databases
ENSO	El Niño Southern Oscillation
GEF	Global Environment Facility
GDP	Gross domestic product
GHG	Green House Gas
GVP	Gross Value Product
HDI	Human Development Index
HPI	Human Poverty Index
ICZM	Integrated Coastal Zone Management
IGCI	International Global Change Institute
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KGA	Kastom Gaden Association
MDGs	Millennium Development Goals
MoH	Ministry of Health, Vanuatu
NDG	National Development Goal
NACCC	National Advisory Committee on Climate Change
NDMO	National Disaster Management Office
NGO	Non-governmental organisation
PACC	Pacific Adaptation to Climate Change
PICCAP	Pacific Islands Climate Change Adaptation Project
PICTs	Pacific Islands countries and territories
PNG	Papua New Guinea
SEI	Stockholm Environment Institute
SLR	Sea-level rise
SOPAC	Pacific Islands Applied Geoscience Commission
SPREP	Secretariat of the Pacific Regional Environment Programme
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
V&A	Vulnerability and Adaptation Assessment

Executive Summary

Background

In the future no country will be immune from the impact of human-induced climate change. The Intergovernmental Panel on Climate Change (IPCC) is unequivocal in its pronouncement that global warming will cause significant climate changes throughout the world, including increases in air, sea surface and ocean temperatures and influencing pattern of precipitation, wind flow and ocean salinity (IPCC 2007). The world is expected to experience increased climate variability as well as extreme weather events, such as prolonged drought, heavy rains and heat waves, and the increased frequency and intensity of tropical cyclones. Sea level rise is also predicted. The effects of such changes will be significant to all the Pacific Island countries and territories (PICTs), although the nature and degree of the socioeconomic impact of climate change cannot be predicted with any certainty at this point in time.

This Melanesia project, undertaken by the Bishop Museum and SPREP, is part of a John D. and Catherine T. MacArthur Foundation initiative to help understand better adaptation strategies suited to local circumstances, which are based on local information, good governance and through the strengthening of conservation practices. Its key objectives are to:

- undertake an initial vulnerability assessment based on known information and current management practices; and
- assess information gaps and capacity needs for implementing adaptation strategies.

This review report addresses the *Institutional and Socio-economic Assessment* component of a three-part project:

- *Scientific Assessment* – an assessment of scientific understanding of the impact of climate change on island and marine ecosystems in Melanesia (to be undertaken by the Bishop Museum);
- *Institutional and Socio-economic Assessment* – an assessment of the institutional and socio-economic adaptive capacity of Melanesian countries to respond effectively to climate change impacts including legislation, policies and capacity assessment (to be undertaken by SPREP); and an
- *Integrated Scientific-Socioeconomic-Institutional Assessment* – an integrated assessment of the vulnerability of Melanesia's biodiversity to climate change, based on the above (to be undertaken by the Bishop Museum and SPREP).

The effect of climate change in the Pacific is examined from a perspective more broad than the original biodiversity focus because climate change for the Pacific islands is more than an environmental issue. Climate change is a development issue that concerns human livelihoods and social well being as these are closely intertwined with biodiversity issues (i.e. ecosystem health). This study draws on Pacific-wide information to provide an overview of the situation, particularly in light of the limited, robust technical and empirical information available specifically for Melanesia. The purpose of this largely literature-based review report is to provide an overview of:

- expected economic costs of climate change, climate variability and sea level rise in the Pacific, including Melanesia;
- gaps in knowledge about economic cost of climate change;
- key adaptation strategies needed to strengthen socio-economic resilience; and capacity development needs for strengthening resilience to climate change.

Thirteen recommendations are made covering:

- analytical approach to use when assessing economic costs of climate change; vulnerability assessment and assessment for developing "no regrets" adaptation strategies;
- baseline information required to assess economic costs, and necessary information needed to underpin context specific initiatives for adaptation to climate change;
- necessary strengthening of governance arrangement at all levels for reducing sensitivities, risks and vulnerability to climate change; and
- institutional and human capacity development.

I. Climate Change

Currently, the limited scientific evidence from the Pacific indicates that PICTs are already experiencing various levels of effects of climate change, with the central equatorial region showing stronger warming effects than the areas further away from the equator.

With global warming, El Niño weather patterns have become more frequent, bringing an increase in rainfall in the Northeast Pacific and a decrease in rainfall in the Southwest. Even within a country, it is expected that some parts of the country may experience drought whereas other subregions may have increased precipitation. Each El Niño event in the past has resulted in water shortages and drought in some parts of the Pacific (e.g. Papua New Guinea, Marshall Islands, Samoa, Fiji, Tonga and Kiribati), and increased precipitation, and flooding in others (e.g. Solomon Islands, and some areas in Fiji). With El Niño, ocean patterns are also expected to change, influence primary and secondary productivity in the Pacific and define core habitats of the marine flora and fauna species, in particular tuna.

Sea level rise is also being experienced in many parts of the region and expected to increase by 0.19-0.58 cm by the latter part of the 21st century.

II. Effects of climate change and variability and sea level rise[1]

For those PICTs that are located along the equatorial belt, regularly experience climate and hydro-meteorology related disasters, including cyclones, high winds, increased rains, floods, droughts and storm surges. During 1950-2004, the Pacific experienced 207 natural disaster events and incurred over US$6 billion in damages, according to the World Bank (2000). Of these disasters, cyclones alone accounted for 76 per cent of the reported events, accounting for almost 90 per cent of total costs and 79 per cent of the fatalities associated with these natural disasters. The majority of other natural disasters were floods, droughts and storm surges (Figure 1), with floods believed to cause more fatalities and general devastation with concurrent effects of violent winds, high waves and storm surges (Terry et al. 2008).

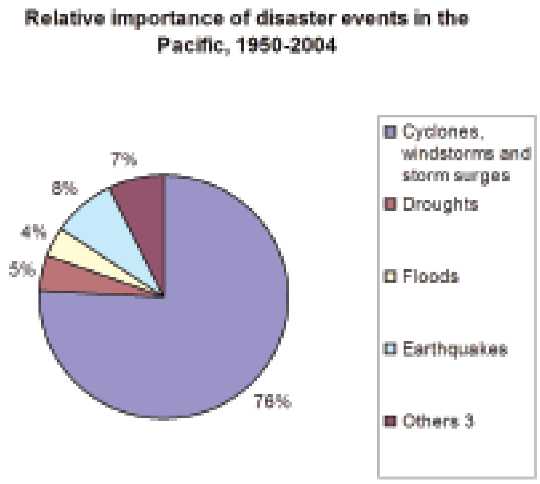


Figure 1: Relative importance of disaster events in the Pacific, 1995-2004

With climate change, such events are expected to increase in frequency and intensity, and their impacts will drastically jeopardise the ability of communities to avoid the clutches of poverty. The ability of countries to achieve their national development goals, including the Millennium Development Goals (MDGs), will also be compromised.

III. Economic Costs

The economic cost of climate change is a result of the complex interaction between climate and hydro-meteorological characteristics, and their direct and indirect impact on the environment and human activities, along with the economic costs (and benefits) associated with them and subsequent impact on human

[1] From here on, the term climate change is used to refer to climate change, climate variability and sea-level rise.

livelihood. Direct impacts of climate change occur during or immediately after a natural hazard event, such as damage to crops and buildings from high winds and flooding. They may also include heat strokes, asthma and respiratory illnesses, affecting human productivity. Indirect effects are flow-on impacts that occur over time after a hazard event. They are caused by the direct impacts of a disaster, such as rise in water and vector borne diseases that result from increased precipitation and flooding and poor sanitation. Temperature increases and sea-level rise interact with island topography (coastal low-lying lands, versus steeper inclines) and with the other physical, social, and economic conditions in determining the consequences of extreme climate changes and the islands' vulnerability to them.

All walks of life in the Pacific are expected to be impacted, and in extreme cases human security, and even survival of nation states, will be in jeopardy. The impact will be experienced at all levels: the household level, the sector level or the national level (i.e. the financial costs borne by the government, communities and non-governmental organisations).

To understand the economics of climate change, three sets of knowledge are useful:

- 'A' – scientific (i.e., meteorological understanding of the effects of green house gas emissions, global warming; and its effects on rainfall and temperature pattern, sea-level rise, and oceanic patterns);
- 'B' – direct impacts (i.e., hydro-meteorological changes on ecosystems, infrastructure and human capital); and
- 'C' – economic impacts (i.e., the costs of changes on human livelihoods and government finances.)

Methodology

Presently, only a few studies have directly addressed the issue of economic costs of climate change in the Pacific, although there are relatively more studies completed on the economic cost of past natural disasters. These studies have generally adopted economic impact assessment methods commonly used globally, including:

- disaggregated techniques – i.e. the consideration of the physical impacts of climate-related (and other) disasters on the economy, on human life and on the environment; and
- economic models, including integrated sector level assessment models.

To assess the economic costs of climate change, four analytical methods have been employed, either individually or in some combination – modelling, empirical judgment, expert judgment and anecdotal information – have been used to assess the costs of climate change. The specific method used depended on the specific aspect of climate change being considered, and the availability of context-specific scientific, economic and social information. While some rigorous scientific analyses were attempted, these often focused on one of the components: climate modelling, ('A'), sectoral impact assessment, ('B'), or economic assessment, ('C'). Methods adopted included:

- Quantitative economic estimation using climate change impact models, supported by scientific impact assessment and climate model simulations, covering all three sub-categories of empirical analysis, 'A', 'B' and 'C' (Figure 2).
- Qualitative economic impact 'assessment' based on rigorous context-specific scientific assessment of climate change ('A'), and limited impact assessment ('B'); and
- General qualitative commentary on the nature of climate impacts on economic activity and people, using predicted climate change scenarios of IPCC and general country-specific environmental, economic and social characteristics knowledge.

Generally, past climate and disaster impact assessments suffered from poor information, as many of the studies were partial analysis. It is evident from the limited studies in the Pacific that without rigorous economic costs analysis based on a holistic and integrated approach, only partial understanding of the economic costs of climate change is possible.

Recommendation 1: *Adopt an integrated analytical approach to determine economic costs of climate change and variability, which also includes rigorous scientific modelling, sensitivity assessment as well as 'with and without' economic cost analyses.*

Economic Cost Estimates of Climate Change – National

Recent studies of past natural disasters in the Pacific estimate average natural disaster-related costs to be around 2-7 per cent of their national Gross Domestic Products (GDPs) (World Bank 2000). These costs are similar to globally reported average costs, although in absolute terms Pacific costs may appear relatively small. Costs to the PICTs since the 1950s has been in the order of US$2.8 billion (World Bank 2005), with Melanesian countries, because of their geographical attributes, generally suffering the largest number of disaster events and experiencing large impacts on people and the economy.

Individual natural disaster events are known to have had major local impacts. Vanuatu, for example, during past natural disaster years suffered on average economic losses of 30 per cent of their nominal annual GDP, or about Vatu 300 billion (World Bank 2005). At the sector level, Cyclone Ivy affected 90 per cent of water resources, 70 per cent of roads, 60 per cent of health infrastructure, and over 80 per cent of food crops. It is projected that similar, if not higher impacts are expected in the future. Under a worst case scenario of future cyclone events, the World Bank has estimated that Vanuatu could stand to lose as much as AU$260 million, which is about 130 per cent of their recent 30-year average real GDP of AU$195 million. On the other hand, insurance damage assessment of infrastructure in Port Vila suggested an economic cost as high as AU$640 million (Shorten et al. 2003).

The nature and extent of economy-wide impacts depend on a complex interaction of factors, including the nature of hazard, the state of individual well-being, local and national economic structures and the economic policy environment. Economic cost of climate change is also a function of the status of current economic activities, including infrastructure, and current vulnerability of the natural capital, people's livelihoods and economies. The effects of flow-on impacts in the Pacific, which tend to affect basic conditions of human livelihoods, are likely to last over a much longer period than the direct impacts.

The negative impacts of natural disasters have far-reaching impacts on national development efforts, including social development, with natural disasters in Fiji known to cause – as expected – a decrease in expected household disposable income. Conversely, the number of people affected by disasters is also a function of the development status of the country. The lower the Human Development Index (HDI), the greater is the number of people affected by disasters. With expected increases in climate-related disaster events, countries are expected to struggle to meet their development needs, despite making good progress in some MDG indicators, such as gender equality.

These impacts will affect national government fiscal situations and their ability to meet peoples' needs and aspirations, including:

- higher expenditure and/or the partial reallocation of already committed financial resources (usually from the capital budget), both to meet the costs of repair and rehabilitation of public property and to provide support to the victims;
- a fall in government revenue as lower levels of economic activity, including possible net falls in imports and exports, imply reduced direct and indirect tax revenue; and
- an increase in budgetary pressures, which may result in governments borrowing more, thus placing inflationary pressures on the economy.

Countries that experience a higher incidence of natural disasters tend to achieve lower rates of growth, as documented for Fiji and elsewhere in the world (Benson 1997). Countries that are heavily reliant on the primary sector are generally found to be more sensitive to the effects of natural disasters (Benson 1997; Benson and Clay 2004). This is particularly true for the Pacific, where the primary sectors, such as agriculture, forestry, fisheries and tourism, account for 23–54 per cent of the national GDPs, with most economies relying on just a few commodities.

Climate change effects can further constrain national development efforts, and impede the achievement of development targets. Similar sentiments were also recently expressed at the United Nations (UN) Human Rights Open Consultative Meeting organised by the UN Office of the High Commissioner for Human Rights on 22 October 2008, when it was noted that MDG 1 (poverty), MDG 2 (education), MDG 7 (environment, in particular target 10 for access to clean water and sanitation) are not likely to be met by 2015.

Economic Costs of Climate Change – Sector level impacts and human livelihoods
The gravity of the potential impacts of climate change becomes more apparent when one considers sectoral level impacts, including those on human livelihoods. Livelihood comprises the capabilities, assets and activities required for making a living by an individual or a group of people. Livelihood is considered to be sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, both now and in the future (Carney 1998). The ability to cope with and recover from external shocks depends on, amongst other things, the health of natural resources and supporting ecosystems (natural capital asset), human health (human capital asset), physical infrastructure (physical asset) and financial resources (financial asset) available to people. It is also dependent on the sensitivity of the respective sectors and capital assets as well. Sensitivity can be seen from the perspective of individuals, communities and states. At the household level this can be further divided into things such as food sensitivity and livelihood sensitivity. Vulnerability also depends on the coping capacity at the individual household and community levels as well as government financial and institutional capacity to respond. On these fronts, Pacific communities are weak and thus highly sensitive to external shocks.

Primary Sectors
For the people of the Pacific Islands, agriculture, fisheries, and tourism, and core natural ecosystems and resources – coral reefs, mangroves and water – are central to their livelihood and wellbeing. Each of these sectors is also highly sensitive to the effects of climate change.

Agriculture
Limited empirical studies confirm that the cost of climate-related disasters on the agricultural sector can be very significant, with estimates ranging from US$13.8 million to US$14.2 million. This is equivalent to a reduction in agricultural Gross Value Product (GVP) by about 26 per cent and a GDP reduction by 1.3 per cent (World Bank 2000). When direct and indirect costs are included, costs associated with single events could be even higher. For Cyclone Ami that hit Vanua Levu in Fiji in 2003, a US$33 million loss was reported (McKenzie et al. 2005), mainly due to flood damage of agricultural crops. In New Caledonia, the estimated cost of damage to agriculture by Cyclone Erica in March 2003 was US$13 million (DAVAR unpublished, quoted in Terry et al. 2008).

In the future, due to climate change, such effects on the agricultural sector could be much higher. The projections by IPCC Assessment Report 4 (AR4) suggest that the Pacific Islands could expect to see, with moderate levels of certainty, an increase in the wind speeds of 0-20 per cent, even if there are no expected changes to the frequency of cyclones, (though modelling results give conflicting projections)

The indirect effects of increased inundation of sea water in coastal areas could lead to the temporary loss of productive areas and deterioration in soil quality, with possible longer term impacts. Atoll islands and low-lying areas are in an especially vulnerable position to sea-level rises given their limited availability of agricultural land. Where sea-level rise causes permanent damage, consequences could be much more disastrous for people residing in coastal areas, with people being forced to relocate. More commonly, storm surges and increased salt water intrusion would limit the range of crops that could be grown, and exacerbating existing threats to food security. However, in some cases, when interpreting such changes some caution is warranted, particularly when attributing observed changes to a particular cause, such as climate change, where in fact it may be tectonic activity or anthropogenic factors that is the cause.

National level average statistics mask the impact of climate change to the peoples' livelihood, particularly as subsistence and commercial activities in the primary sectors, including agriculture, contribute on average between 20 and 55 per cent of the national GDPs. In many countries, subsistence agriculture is the main source of food and household wellbeing.

Following cyclones and other natural disasters, especially drought, communities in some countries, such as Solomon Islands and Papua New Guinea (PNG), often face extreme hardships. At times food shortages are experienced not only during the disaster events but also for extended periods of time after the event has passed. Such hardships have been so common that the locals even have coined terms such as or *'time blong hungry',* due to subsistence food shortages as well as due to income shortages. Being reliant on a few commodities, such as copra, some rural communities could be without any income for several years when coconut trees fail to produce fruits after cyclone damage. Furthermore, communities have become particularly vulnerable in some cases because of the weakening of traditional ties and social safety nets due to modernisation (Warrick 2007).

Fisheries

Climate change will also have a major impact on the fisheries sector, affecting both the offshore tuna fisheries, which is a major source of foreign exchange, and coastal fisheries, which are important for local food and nutrition security. These impacts, however, will vary across the region, depending on the importance of these two sectors on a nation's GDP and lower-level household livelihoods.

Tuna fisheries

Effects of global warming on the tropical Pacific Ocean would mean climate conditions similar to present-day El Niño, causing increased interannual variability on ocean conditions, affecting the distribution and productivity of western and central Pacific tuna stocks and fisheries. Some island countries expect to see a decline in tuna stocks while others, such as the Melanesian countries, could expect an increase in tuna stocks due to climate change-induced changes in their migratory patterns.

Because of the migratory nature of tuna, the location of areas of high/low tuna catch shifts during the different ENSO phases is, however, difficult to predict at present. Many distant water fishing nations' (DWFNs) fleets have access arrangements with several PICTs and these would be able to adapt to changes in the spatial distribution and abundance in tuna stocks. Domestic fisheries in PICTs, on the other hand, would be confined geographically to their exclusive economic zone (EEZ), and thus less able to adapt to climate variability and future climate change. In the long term the DWFNs may wish to renegotiate the terms and conditions with PICTs, including access fees. Some PICTs may win while others, particularly in the eastern Pacific, may lose and this could possibly jeopardise regional solidarity during multilateral tuna access fee negotiations in the future. The vulnerability of national economies to changes in revenue generated from tuna fisheries will also increase because of the differential importance of tuna fisheries in domestic economy for some PICTs.

Coastal ecosystems & food and nutrition security effects of climate change

The effects of climate change on the coastal fisheries will be experienced through changes to the coastal ecosystems, in particular coral reefs and mangroves. With any changes in coastal fisheries, countries can expect to see a drastic impact on household and community livelihoods and wellbeing, with a reduction in their ability to meet their basic food and nutritional requirements. The economic costs of climate change on coastal fisheries are, however, difficult to predict, because of the limited knowledge regarding complex dynamics of particular coastal ecosystems and the multifaceted nature of peoples' dependence on their goods and services.

Impact on coral reef ecosystems

Coral reefs, are valued for their goods and services which support subsistence, artisanal and commercial fisheries, as well as providing building materials in some PICTs and supporting recreational (e.g. diving) and nature-based tourism. Coral reefs are also valued for their role in coastal protection. With the projected increases in sea-surface temperatures, the thermal tolerances of reef-building corals are likely to be exceeded within the next few decades. Climate change effects include coral bleaching, with major bleaching events reported in the last decade in Fiji and PNG (Davies et al. 1997). Globally, coral bleaching in 1998 is known to have led to a loss of 16 per cent of the world's coral reefs. However, economic impacts and recovery patterns are not uniform.

More importantly, climate change will add to the already existing stresses on the coral ecosystems due to human activity on land and the sea. Most PICTs countries have reported concerns about over-fishing, pollution and habitat destruction. Such effects are often localised and their cumulative effects can vary from low to very high within a country. Throughout the Pacific, coral reefs are reported to be under considerable stress and climate change will exacerbate the effects on commercial and subsistence fisheries as well as tourism.

Empirical assessment of the economic cost data on the effects of climate change is limited to a few studies. A World Bank study in Fiji estimated an expected loss in commercial fisheries for Viti Levu to be in the vicinity of US$0.05-0.8 million with a further loss in subsistence fisheries at between US$0.1-2.0 million, whereas the loss in coastal habitats is valued between US$4.8 and US$10.8 million. In the absence of detailed scientific information, these estimations were based on some broad assumptions (e.g. the functional relationship between climate change and changes in fish production).

Mangroves
Recent analysis of the impact of sea level rise in the Pacific indicates that the region could lose about 13 per cent of the 524,369 ha of mangroves by 2100. Of these, 83 per cent will be lost from the Melanesian countries with significant economic costs. Using economic values of mangroves reported for the Pacific (Lal 1990; Naylor 1998), the economic cost of the loss of these mangroves by 2100 could be in the range of US$24 million to US$470 million per year, with the latter estimate reflecting other considerations of ecosystem services, such as foreshore protection. Once again these national cost estimates mask the local level vulnerabilities of communities, such as those at Crab Bay in Vanuatu, who are largely reliant on mangrove resources for their food and income security (Hickey 2006).

Coastal zone and infrastructure
The majority of populations in PICTs reside on the coast or on islands. Most of the key infrastructure, such a hospitals, power stations, fuel tanks, farms, schools, and town and cities are also often located in these coastal and island regions. With an increase in magnitude and frequency of storm events and sea-level rise, coastal areas will be under further increased risks of inundation, flooding, erosion and associated physical damages. Climate change will also present several challenges for transportation in PICTs, including the closure of roads, airports and bridges due to flooding and landslides and damage to port facilities. The resulting disruption on infrastructure would also have implications for service delivery in other sectors including tourism, agriculture, health and education, and thus have significant impacts on water and sanitation, food security and markets.

Estimates of the economic cost of infrastructure impacts of climate change (and natural disasters) are limited, although there are some reports of qualitative descriptions. Infrastructure economic costs depend on the scale of infrastructure development in specific PICTs and the intensity of the hazard. In Vanuatu, for example, infrastructure and associated costs for Port Vila under a worst-case scenario is estimated to be about AU$640 million for Port Vila (Shorten et al. 2003). On the other hand, the World Bank estimates the effect of one in 50-year storm event in Fiji and associated inundation could damage about 0.6 to 5.9 per cent of coastline and produce an estimated annualised economic cost in Fiji of about US$3 to US$6 million (World Bank 2000). The infrastructure costs associated with Cyclone Ami were estimated to be FJ$5.8 million or US$3.5 million (McKenzie et al. 2005). Such infrastructure costs are expected to increase as PICTs further urbanise, with an expected 1 in 2 persons residing in urban towns and cities by 2015.

In summary, the implications of climate change for infrastructure and human settlements, particularly rapidly growing urban centres along the coast, are not well understood for the region. Available evidence suggests that the impacts will be significant and could easily undermine private sector-led economic development and reverse gains made in relation to reducing poverty and vulnerability.

Water
Secure access to clean water is a basic survival issue. All the countries in the Pacific report reasonable access to water[2], except PNG and the Federated States of Micronesia (FSM), although many households in rural areas usually have limited access to safe drinking water. Even where there may be universal access to water, water quality is not always assured, affecting basic health as well as water and vector-borne diseases.

Any changes to the water cycle is expected to cause increased problems of access to safe water and affect many human development goals, including the MDG 7 Target 10 on access to clean water and sanitation.

[2] Reasonable access is defined as "the availability of 20 litres per capita per day at a distance no longer than 1000 metres" WHO and UNICEF (2000). *Global Water Supply and Sanitation Assessment 2000 Report*, World Health Organisation and United Nations Children's Fund Joint Monitoring Programme for Water and Sanitation.

Recent ENSO associated droughts have caused some of the worst water shortages on record across much of the Pacific, with many countries declaring emergency situations. Lack of water for human consumption can be a serious issue, particularly on atoll islands, which often rely on limited sub-surface shallow water lens, or rainwater capture. The indirect effects of increased precipitation include the damage caused by flooding, increased incidence of water and vector-borne diseases as well as increases in food prices. Limited water availability is also expected to affect basic human hygiene, with countries reporting increased incidence of water-borne diseases such as diarrhoea. Correlation between temperature, rainfall, and water-borne diseases are mixed (Singh et al. 2004; SPREP, nd #2452). With expected increases in the variability in drought events, as well as increased precipitation, water-related human health effects are likely to be magnified. These will be compounded by the effects of salt water intrusion into sub-surface freshwater lens due to sea level rise.

Economic costs of health effects
Information about the economic costs of climate change-induced human health effects associated with water and insect-borne diseases across the Pacific are poor. To give an indication of the magnitude of economic costs of the effects of climate change on water related health issues, a preliminary analysis of national level health and disaster statistics in Vanuatu was undertaken. Partial analysis suggests a correlation between increased incidence of water-borne diseases and increased rainfall in years when the country suffered a series of cyclonic events. For example, during the period 2002-2003 when Vanuatu saw five cyclone events, malarial incidence increased by almost 50 per cent as compared with the period 2001-2002. Similarly, water-borne disease incidence, such as of diarrhoea, increased by almost 100 per cent over the same period.

Assuming Vanuatu experiences just one extra cyclone event with the associated increase in water- and vector-borne diseases, direct medicinal costs associated with treating such diseases could be about Vatu 6-14 million or about AU$542,000-$600,000 a year. It is strongly emphasised that this is only an indicative cost of climate-related diseases. A much more detailed 'with and without' economic analysis is required that includes not only the economic cost of medicine but also other direct costs, such as the cost of foregone earnings, transportation costs used in Tuvalu, where a cost of AU$500,000 was estimated for a population of 10,000 (Lal et al. 2005). There are also other intangible costs which also need to be taken into consideration. The economic cost of health effects of climate change must also estimate the incremental cost associated with climate change per se. However, this too is fraught with difficulties as functional relationships between climate change and diseases are context-specific and would depend on not only on the geophysical characteristics of the location, but also the health status of people and the availability of health services in the region.

Tourism
Climate is an important aspect of tourism experience, with good weather, sandy beaches and safe coastal settings being some of the major attractions. Climate influences the length and quality of a tourist's experience. Climate also affects a wide range of environmental resources that are critical for tourism attractions, such as diversity of habitat and species of animals and plants, water levels and quality. Climate also affects a number of environmental conditions, such as water-borne diseases, algal bloom, jelly fish infestations that can deter tourists.

Any climate-induced changes to natural ecosystems utilised by the tourism operators may deter potential tourists to the Pacific. In the region, diverse colourful and healthy corals supporting a large diversity and abundance of colourful coral and fish species and the presence of megafauna, such as sharks, manta rays and turtles, are some of the attractions for the tourists. While local information is not available, the IPCC Working Group 2 (WG 2) quoted global surveys which indicate that 80 per cent of tourists would not wish to return to bleached coral areas.[3] Climate can also pose a severe risk in relation to extreme events such as hurricanes and floods. Increased climate variability in weather conditions at a given location and time may also discourage tourists from engaging in their planned activities. These put both tourists and tourism-oriented businesses at risk, including damage to tourism infrastructure and increased financial costs combined with lower incomes and revenues. For many PICTs, such impacts can impede their ability to meet their basic development goals.

[3] IPCC WG2 SPM March 2007

Any decrease in tourism visitation may impact on national economies, particularly when tourism is seen as a major source of economic growth in most countries. In Vanuatu, for example, if the number of tourists were to decrease by one per cent, the expected foregone earnings will be about AU$25 million in direct tourist expenditure annually, or close to about 12 per cent of national GDP.

Forestry

Forests have always been an integral part of the lives of PICTs communities, particularly those who reside on high islands. The continued provision of products and services by forest ecosystems is increasingly under threat from climate change. Climate change is also expected to exacerbate the effects of unsustainable forest uses in the Pacific. The loss of forest areas through agriculture conversion, forest degradation arising from unsustainable logging, forest clearance for development and plantation establishment, are all contributing to the sensitivities associated with the effects of climate change. Deforestation and the loss of forest genetic resources also mean that future option values towards mitigation and coping against climate change will also be hampered. However, the economic costs of such impacts are not known as baseline information on the effects of climate change on local species and ecosystems is not available.

Concluding remarks

Climate change and climate variability will have a significant impact on key sectors that support the basic livelihoods in the Pacific. Changes in local economic activities will affect national economies, as well as on governments' ability to provide key social services delivery. Sectoral impacts of climate change will directly and indirectly affect the key livelihood assets that support human livelihood at the individual, household or community level.

Climate change manifested in rising sea levels and more intense droughts and storms, could also stimulate large scale movements of people within, and across, international borders. Nationally, because of the presence of customary tenure, any displacement of people may have serious problems related to access to land for settlement. For atoll nations, the longer term sea-level rise could also have sovereignty implications. Individually or collectively, such developments could destabilise nations internally, aggravate tensions between PICTs and endanger human security. This concern was reaffirmed by many PICTs as well as the United Nations Security Council in 2008.

> ***Recommendation 2:*** *Urgently develop/strengthen specific geo-referenced baseline information related to key hazards, including socio-economic information, livelihood assets and their sensitivities to climate change.*

IV. Adaptation Strategies

Climate change is not a question of 'if' or 'when'. Climate change impacts are already being experienced throughout the region. The critical issue is 'what?' individually and collectively can be done to minimise vulnerabilities of our communities, economies and environment to the effects of climate change.

There are three core categories of strategies that are relevant for improving adaptation to climate change – poverty-focused development strategies; disaster risk reduction and disaster management; and sustainable resource and environmental management.

By improving the economic wellbeing of people, the diversity of food and nutrition and income sources, and general wellbeing, including basic improvements in access to water and sanitation, countries can reduce vulnerability and increase their ability to respond to disaster events. Improvements in basic human health conditions and human skills and capacity to improve their productivity also reduce vulnerability. Similarly, strengthened resource and environmental management can also help to conserve natural capital and maintain ecological integrity, reducing the scale and extent of impacts from climate change.

Mindful of the encompassing nature of the climate, there is an urgent need to also look at the wide range of adaptation measures across a variety of sectors. Efforts to reduce disaster risk, to improve preparedness of households and communities to disasters, as well as improved early warning and communications strategies can all help increase adaptation to climate change. Tandem improvements in water and sanitation management, integrated catchment management, ecosystem-based management, and/or integrated coastal zone management, and an early-warning and communication system, are necessary if climate change and disaster risk reduction are to be tackled effectively.

Practice in the Pacific
Most vulnerability and adaptation assessments at the national levels have been carried out in the context of the preparation of initial national communications and specific community based projects (e.g. WWF 2008). Adaptation activities in the region have largely been implemented with external support and have had a strong community-based focus, with projects focusing on coastal zone management, water resources management, food security and human health. A number of lessons were learned from the various projects and programmes, including the Asian Development Bank (ADB) project entitled Climate Adaptation in the Pacific Islands (CLIMAP), and Assessment of Impacts of and Adaptation to Climate Change in Multiple Regions or Sectors (AIACC). Key observations from these projects include:

- past studies of adaptation options for PICTs have largely focused on adjustments to sea-level rise and storm surges associated with tropical cyclones;
- early emphasis on protecting land through 'hard' shore-protection measures rather than on other measures such as accommodating sea-level rise or retreating from it, although the latter has become increasingly important on continental coasts;
- vulnerability studies conducted for selected small islands within the PICTs show that the costs of overall infrastructure and settlement protection is a significant proportion of GDP, and well beyond the financial means of most small island states; and
- recent studies since the IPCC Technical Assessment Report (TAR) have identified major areas of adaptation, including water resources and watershed management, reef conservation, agricultural and forest management, conservation of biodiversity, energy security, increased share of renewable energy in energy supply, and optimised energy consumption to increase effectiveness of adaptation measures.

The Forum Leaders have signed two regional plans that directly deal with risk management-related subjects relevant to climate change adaptations – Pacific Islands Framework for Action on Climate Change and the Disaster Risk Reduction and Disaster Management Framework for Action, both endorsed in 2005. These frameworks reflect that disasters, including those related to climate change, are a development issue and that disaster risk reduction and adaptation to climate change will require a multi-pronged approach. The real challenge is in the operation of these commitments, particularly when the existing organisational arrangements, policies and plans, as well as external assistance encourage compartmentalisation, and agencies are working in isolation.

In-country governance
PICTs have implemented many discrete activities directly targeting climate change, usually through their environment departments. At the same time, disaster risk management related-activities have been promoted and or implemented through national disaster management offices, or their equivalent. External assistance has usually provided support through these respective thematic areas, some of which were provided with the assistance of the regional organisations mandated to address these issues under the Pacific Plan. For example, SOPAC for disaster risk management; and the Secretariat of the Pacific Regional Environment Programme (SPREP) for climate change. Under the Pacific Islands Framework for Action on Climate Change (PFACC) and Disaster Risk Reduction and Disaster Management (DRR&DM) frameworks, efforts to mainstream disaster risk reduction and adaptation into national development planning have been highlighted as a priority.

***Recommendation 3:** Develop an integrated Disaster Risk Reduction and Disaster Management Plan of Action that includes climate change-related hazards.*

In many countries, including Solomon Islands and Vanuatu, these two frameworks of action have largely been implemented independently of one another, usually with the assistance of external agencies. Regional partners, too, have had difficulty in integrating the strategies and coordinating their assistance. With limited capacity, PICTs are struggling to integrate these two external sets of assistance, often targeted at the two different parts of the government. There is thus an urgent need to integrate the two streams of assistance to countries to develop a single risk minimisation and risk management plan of action that deals with natural disasters, whether they have their origins in natural climatic events or those induced by human induced climate change.

Sector level governance

Given the levels of uncertainties in the scientific knowledge about climate change and its impact, but also the state of PICTs' national development and resource management efforts, PICTs should initially focus on adopting a sound 'no regrets' approach to climate change that seeks to build resilience to existing known climatic/oceanographic variability and extremes. These may include specific priority climate change-related issues under one or more of the livelihood assets as well as disaster risk preparedness and responses, including:

- Basic livelihood issues (i.e. food and nutrition security);
- Basic human wellbeing (i.e. access to safe water and adequate sanitation, control of water- and vector-borne diseases, human health services);
- Ecosystem management and restoration activities;
- Disaster preparedness and response (i.e. early warning systems, including appropriate disaster response messages and information); and
- Improved shelter and other infrastructure (i.e. appropriate housing and coastal planning and zoning).

It is critical that such adaptation strategies are community-focused, incorporating targeted risk reduction as well as resilience building. Adaptation approaches must seek win-win options whereby actions today help meet immediate needs for reducing risks but also create the basis for reducing future vulnerabilities and the capacity for more effective adaptation as impacts of climate change become more predominant (IUCN et al. 2003).

In PICTs, there is a need for tandem national level efforts to mainstream practical climate change adaptation strategies across all sectors and national planning and budgeting processes. Mainstreaming of climate change and disaster risk management into their national planning and budgetary processes is seen as part of an effort to place member countries in the driver's seat. Its benefits include the adoption of systematic and programmatic approach for guide countries' own efforts, as well as seeking coordinated and harmonised development partners assistance to complement their own initiatives.

The strong two-way relationship between poverty and climate and other disasters suggests countries must particularly focus on communities and areas with poor economic and other human development conditions, as well as sectors that are highly sensitive to climate change and climate variability. At the implementation level, climate change adaptation must target specific sensitive areas as well as coping mechanisms, encourage people to adopt strategies to reduce their own risks, and increase their capacity to respond and cope with climate change impacts.

Recommendation 4: *Target communities and areas with poor economic and other human development conditions, as well as those that are highly vulnerable to climate change effects.*

Risk considerations must also become one of the criteria for the selection of projects, for their design, project implementation and monitoring and evaluation. At the sectoral planning level, as well as project identification, design and implementation, disaster risk reduction concerns must be incorporated, using best available information and analytical methods and tools.

Recommendation 5: *Strengthen existing governance arrangements by establishing organisational arrangements aimed at improving coordination of decision-making processes for policy formulation, planning and budgeting, programme design and implementation, and monitoring and reporting, on climate change adaptation and disaster risk management.*

Tools for identifying adaptation strategies

Several different tools are reported in disaster risk reduction and disaster management literature available, including comprehensive hazard risk assessment and management, root case analysis, problem tree analysis, reported in the disaster risk reduction and disaster management literature. IUCN/IISD/SEI et al (2003) have proposed a three-stage process, each with several steps, which could form the basis for developing adaptation strategy that brings vulnerability-livelihood interactions to the forefront. Specific tools for mainstreaming disaster risk reduction, including climate change adaptation have been developed by the PROVENTION Consortium (see for example, Benson and Twigg 2007,and other references on the PROVENTION website (http://www.proventionconsortium.org/themes). In the Pacific, SOPAC has produced the CHARM, *Comprehensive Hazard Assessment and Risk Management*, as a 'management tool and/or processes within the context of integrated national development planning process'.

Knowledge, Data Bases, Communication and Awareness

Adaptation responses in all sectors must be guided by sound climatic, social, economic and environmental baseline information. In order to build and maintain optimum environmental resilience to climate change stress, improved understanding and monitoring of climatic, oceanographic, coastal and hydrological systems, human resource use and settlement patterns must be improved. Robust time series data are needed covering disaster events, social, economic and environmental impacts, socio-economic information, as well as macroeconomic information. While some aggregate data is generally made available through PICTs' Bureau of Statistics for monitoring national development goals, including MDGs, these are usually not in a form that can be readily used for vulnerability assessment and that could inform advice on climate adaptation policies and strategic actions. More effort is therefore needed to develop linked and harmonised and geo-referenced information system, and associated technical capacity, required to identify context specific hazards, vulnerabilities, and targeted adaptation measures.

Recommendation 6: *Urgently generate specific baseline information about current and expected trends in natural hazards, population and economic activities, and their sensitivities and develop geo-referenced, harmonised and linked databases using GIS and other modelling tools.*

It is acknowledged that while it may not be possible to build capacity in each PICT to undertake such research, developing capacity at the regional level should still be one of the priorities undertaken to ensure that detailed climate change-related vulnerability assessment that brings together climate predictions ('A'), climate impacts on ecosystems and associated economic systems ('B') and economic cost and livelihood assessment ('C') can be conducted adequately and efficiently. While climate change predictions may be global, regional and national, impact assessment of climate change will need to be area and community specific, and for which context-specific hazard assessment is critical.

Recommendation 7: *Sector level adaptation strategies must initially focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic/oceanographic variability and extremes by targeting improvements in livelihood assets –financial, human, socio-political, physical, and natural capital.*

Vulnerability assessments, together with scientific and traditional knowledge, could be used to develop appropriate adaptation initiatives that are suitable to the local conditions. Context specific adaptation initiatives could be identified using Vulnerability and Capacity Assessment (VCA), which has been used as a key component of disaster risk analysis, including climate change risk analysis (PROVENTION Consortium, 2006). Climate change community based vulnerability assessments have been undertaken using community based V&A tools, such as the one developed by WWF (WWF 2008) and by the CDAMPIC project (SPREP n.d.).

Recommendation 8: *Adopt a holistic and programmatic approach to understand area and community focused vulnerability, bringing together three categories of knowledge: climate change and climate variability; climate change and climate vulnerability effects on nature, people and economies; and costs to livelihoods.*

Recommendation 9: *Using vulnerability and capacity assessment tools, combine scientific and traditional knowledge to develop adaptation strategies and initiatives, including community level initiatives. These initiatives would focus on sound 'no regrets' approaches and risk reduction initiatives suitable for the local social, economic and socio-political context.*

Recommendation 10: *Strengthen enabling environment – organisational arrangements and decision-making processes – to address cross-sectoral issues at national, sectoral and local levels for climate change adaptation and disaster risk reduction.*

Focus on actors and decision-makers

Considering the multidimensional effects of climate change on most aspects of life and livelihood, efforts to increase adaptation to climate change will need to focus on actors and decision-makers across and all levels of society (i.e., government policy-makers, sectoral agencies and managers), as well as well as communities, households and individuals. The ultimate goal of their actions and decisions is to ensure that poor and vulnerable groups develop and improve their basic economic wellbeing to reduce their risks and increase their resilience to external shocks and, finally, sustainably manage their ecosystems and natural resources. To ensure this, actors and decision-makers need to be supported by enabling environments that encourage and facilitate appropriate decisions, producing the desired outcomes.

Practical way forward

In conclusion, climate change is a dynamic phenomenon and its effects will be multifaceted and multidimensional. Given the paucity of the scientific knowledge, adaptation to climate change should be treated as a process rather than a prescriptive solution. Adaptation strategies must initially focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic/oceanographic variability and extremes, and which also lay the foundation for tackling future climate change scenarios. Thus, efforts to address climate change effects must be viewed through the lens of improving decision-making process and making evidence-based decisions within an adaptive management framework.

Adaptation by necessity is a context-specific affair and stakeholder-based VCA can help identify and prioritise specific initiatives for implementation. To successfully address governance issues at all levels and to improve stakeholder decision-making process, particular attention needs to be paid to institutional and human capacity development. Such initiatives can be guided by key principles and strategies identified in various regional sectoral and thematic policies and plans.

Adaptation to climate change is everyone's business. For sustainable adaptation to climate change, there is a need to pursue pro-poor development strategies as well as the implementation of various sectoral and cross-thematic regional policies, such as the Disaster Risk Reduction and Disaster Management Strategies and Pacific Island Regional Action Plan on Climate Change.

Recommendation 11: *Make climate change adaptation and disaster risk reduction everyone's business through communication, advocacy, and leadership training.*

Recommendation 12: *Develop capacity at all levels of society and across all aspects of livelihoods – individuals, community, sector national development agencies, sectoral managers, and policy-makers – to make informed decision and choices.*

V. Data Requirements

Baseline information is very limited at best and almost non-existent particularly when socioeconomic information and data for determining economic cost of climate change are concerned. Disaster information is restricted to EMDAT database, and which reports only intensive disasters, where at least 10,000 people are affected. National disaster management offices (NDMOs) maintain some disaster-related information, although these are not complete and what is collected is not available in a form that can be readily accessed.

SOPAC, in collaboration with its Pacific Disaster Risk Management Network, maintains an online *Pacific Disaster Net* database, which contains information in a range of formats including reports, data inventories, maps, contacts, web links, etc. However, this is but a first step. Concerted effort is needed to develop robust and harmonised country-specific empirical national information system, which can also be used for vulnerability assessment to underpin targeted adaptation to climate change.

Much of the primary data about population is available from census data but in many cases these are not geo-referenced, or readily accessible by disaster managers. Some household income and expenditure survey data are available, but these too are outdated and not geo-referenced or can easily be extrapolated to other areas. Broad aggregate-level information is reported against national development goals, including MDGs, making it difficult to do the types of analyses required for climate change adaptation.

Several different types and layers of information are needed to support adaptation to climate change. These include:

- Hazard assessment;
- Household distribution sensitivity;
- Natural capital sensitivity;
- Vulnerability assessment;
- Context-specific adaptation measures; and
- Macroeconomic data.

***Recommendation 13:** Urgently develop harmonised and geo-referenced national information system covering livelihood assets – natural, human, financial, and physical capital – that can be used to identify sensitivities to climate change, adaptive capacity, and key strategies covering pro-poor development, natural resource and environmental management and disaster risk reduction and disaster management.*

Conclusion

PICTs are already experiencing the effects of climate change, even if the economics and social costs of these effects are poorly understood. Detailed analysis into the economics of climate change is limited, and those that have been completed are largely partial, and or incomplete. On the other hand, a relatively larger number of 'with and without' impact analysis of natural disasters, many of which are climate related, has been undertaken in the region. These, too, are still smaller in numbers and scope compared to studies completed for other SID regions. Studies that have been completed are largely qualitiative, providing commentary on the nature of climate impacts on economic activity and people, using predicted climate change scenarios of IPCC and general country-specific environmental, economic and social characteristics knowledge. There are though a limited number of quantitative economic estimates covering climate modelling, technical impact assessment and economic assessments.

For the Pacific, climate change is a development issue, placing increased pressures on their already limited capacity to meet the needs and aspirations of their people and improve basic livelihoods. The real challenge in the region is what individually and collectively can be done to minimise vulnerabilities of the individuals, communities, economies and environment to the effects of climate change.

Adaptation must be context-specific reflecting expected local hazard conditions, the status of environmental, social, economic capital and human capacity. To achieve this, many focused and targeted initiatives are relevant, including climate change, and disaster risk management, being mainstreamed into national planning and budgetary processes as well as sectoral level decision-making processes, placing PICTs in the driver's seat. Mainstreaming will also help countries to adopt systematic and programmatic approach that can help guide countries' own efforts, as well as seeking coordinated and harmonised development partners' assistance to complement their own initiatives. Climate change adaptation must target specific sensitivity areas as well as coping mechanisms to climate change effects, and translate these into actions that people can adopt to reduce their risks, but also increase their capacity to respond to and cope with climate change effects.

Acknowledging that capacity is low and information is limited, including baseline data to make informed decisions, countries must focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic/oceanographic variability and extremes, and which also lay the foundation for tackling future climate change scenarios. Appropriate governance arrangements must be put in place that encourages the cross-cutting nature of climate change issues to be appropriately addressed. Thus, efforts to address climate change effects must be viewed through the lens of improving decision-making process and making evidence-based decisions regarding national development and livelihood as well as resource and environmental management within an adaptive management framework. Simultaneously, every effort needs to be made to improve the knowledge base.

I. Introduction

Climate change refers to the variation in global climate conditions due to the increases in carbon dioxide and other gas emissions from human activities over and above the natural absorptive capacity of the natural system. Excessive carbon dioxide and other greenhouse gas emissions are known to influence the atmosphere and interfere with climate systems, causing the global atmosphere to warm – a phenomenon generally known as 'global warming' or the 'greenhouse effect'.

While climate systems are very complex and there is natural variability that also leads to climatic changes over time, the IPCC in its fourth assessment report (AR4) note that global warming observed in recent times is "very likely" to be human induced (Intergovernmental Panel on Climate Change 2007). Increased greenhouse gas emissions from human activities is affecting the system's dynamics, and causing a change in climatic and related conditions. Amongst the key human activities behind the increased green house gas (GHG) emissions are the burning of fossil fuels which releases carbon dioxide and other GHG, and deforestation which reduces natural carbon sequestration.

The IPCC is also unequivocal in its pronouncement (Intergovernmental Panel on Climate Change, 2007) that global warming is expected to cause significant climate changes throughout the world, including increases in air and sea-surface temperatures influencing, among other things, patterns of precipitation, wind patterns and ocean salinity. Global warming is expected to increase climate variability as well as extreme weather events, such as prolonged drought, heavy rains, and heat waves, and the frequency and intensity of tropical cyclones. Some of the key global findings of AR4 include:

- Expected global temperature is very likely to rise between 2°-5°C in global mean temperatures. Several new studies suggest up to a 20 per cent chance that warming could be greater than 5°C. If annual greenhouse gas emissions remained at the current levels, concentrations would be more than treble pre-industrial levels by 2100, committing the world to 3-10°C warming, based on the latest climate projections;
- Global warming is very likely to:
  - intensify the water cycle, reinforcing existing patterns of water scarcity and abundance and increasing the risk of droughts and floods;
  - increase the risk of abrupt and large-scale changes in the climate system will rise; and
  - changes in the distribution of heat around the world are likely to disrupt ocean and atmospheric circulations, leading to large and possibly abrupt shifts in regional weather patterns.
- Sea level rise, relative to 1980-1999, is predicted to be between 0.19m to 0.58m, by 2090-2099.

No country will be immune from the impact of climate change. Pacific Islanders, because of their geographic location in the tropics and their unique social, economic and environmental characteristics, are among the most vulnerable people in the world to climate change and climate variability. For the Pacific, climate change is, and will continue to be, a development issue. It directly and indirectly affects all aspects of life, environmental, economic and social, and across all levels – individual, household, community as well as the national economy. The nature and degree of socioeconomic impact of climate change expected to be experienced in the Pacific are not known with much certainty.

To address the uncertainty, the John D. and Catherine T. MacArthur Foundation has supported a series of projects to develop a better picture of vulnerability of important biodiversity hotspots globally. The key objective of this initiative is to help develop adaptation strategies suited to local circumstances, based on local information, good governance and strengthening of conservation practices. Under this initiative, the MacArthur Foundation has for the Pacific Islands funded the Bishop Museum and SPREP to undertake the Climate Change and Biodiversity in Melanesia Project. The key objectives of this project are to:

- undertake an initial vulnerability assessment based on known information and current management practices; and

- assess information gaps and capacity needs for implementing adaptation strategies.

The Melanesia project comprises three components:

- *Scientific Assessment* – an assessment of scientific understanding of the impact of climate change on island and marine ecosystems in Melanesia (to be undertaken by the Bishop Museum).
- *Institutional and Socio-economic Assessment* – an assessment of the institutional and socio-economic adaptive capacity of Melanesian countries to effectively respond to climate change impacts including legislation, policies and capacity assessment (to be undertaken by SPREP); and an
- *Integrated scientific-socioeconomic-institutional assessment* – integrated assessment of the vulnerability of Melanesia's biodiversity to climate change, based on the above (to be undertaken by Bishop and SPREP).

This report covers the *Institutional and Socio-economic Assessment*. The effects of climate change in the Pacific are examined from a perspective broader than just biodiversity, particularly because climate change is more than just an environment issue. The specific focus of this report (detailed terms of reference of the economic subcomponent are outlined in Annex 1) include an overview of:

- the economic costs of climate change, climate variability and sea level rise in the Pacific, including Melanesia, and gaps in knowledge about economic cost of climate change;
- key adaptation strategies to strengthen socio-economic resilience;
- data requirements for strengthening evidence based adaptation to climate change; and
- capacity development needs for strengthening resilience to climate change.

The rest of the report, based primarily on literature review, has the following structure:

II. Climate Change in the Pacific
III. Climate Change and its Effects
IV. Economic Cost of Climate Change
V. Adaptation to Climate Change
VI. Data Requirements
VII. Conclusion

Limited country visits to Vanuatu and Solomon Islands helped supplement the desk study and provide some grounding of particularly community level experiences not captured in national level statistics. A list of people consulted for this study is summarised in Annex 2.

The report also makes specific recommendations (13 in all) regarding:

- analytical approach to use when assessing economic costs of climate change; vulnerability assessment and assessment for developing 'no regrets' adaptation strategies;
- baseline information required to assess economic costs, and necessary information needed to underpin context-specific adaptation to climate change;
- strengthening governance arrangement at all levels for reducing sensitivities, risks and vulnerability to climate change; and
- institutional and human capacity development.

II. Climate Change in the Pacific

Weather, climate and ocean current patterns in the Pacific are influenced by several natural contributing factors such as trade winds regimes, South Pacific Convergence Zone (SPCZ), with El Niño Southern Oscillation (ENSO) as the dominant mode for year to year variability. ENSO is an interannual mode of variability in the ocean and atmosphere and it has two dominant phases: El Niño and La Niña, with occasional years in which 'neutral' conditions are experienced. Global warming is expected to be a major factor in accentuating current climate regimes and normal changes that come with ENSO (Folland, Renwick et al. 2003; Hay, Mimura et al. 2003, cited in IPCC 2007, Chapter 16).

Limited scientific evidence from the Pacific indicates that PICTs are already experiencing differential effects of climate change, with the central equatorial region showing stronger warming effects than other areas from the equator. The southern Pacific is, compared to the past, experiencing a significantly drier and warmer climate (by 15 per cent and 0.8˚C, respectively). The central equatorial Pacific, on the other hand, is experiencing more intense rain (representing a change of about 30 per cent) and a similarly hotter climate (0.6˚C). Sea-surface temperatures in North and South Pacific areas have increased by about 0.4˚C (Hay et al. 2003). The longer term will also be different for different parts of the Pacific (Table 1).

Table 1: Projected increases in air temperature (0ºC) and per cent change in precipitation in the Pacific

	2010-2039	2040-2069	2070-2099
	0.49 to 1.13	0.81 to 2.48	1.00 to 4.17
Temperature (°C) Southern Pacific	0.45 to 0.82	0.80 to 1.79	0.99 to 3.11
Precipitation (% change)			
Northern Pacific	-6.3 to +9.1	-19.2 to +21.3	-2.7 to +25.8
Southern Pacific	-3.9 to +3.4	-8.3 to +6.7	-14.0 + 14.6
Sea-level rise (relative to 1980-1999 sea level)	North and south around subtropical region of 90 degree E (2 -2.5 mm/yr to 3 mm/yr) Predicted SLR by 2090-2099 is between 0.19 to 0.58 m		
Wind intensities (% increase)	5-10	-	-
Source: McLean et al. (2007)			

El Niño weather patterns have become more frequent since 1977, bringing an increase in rainfall in the northeast Pacific and a decrease in rainfall in the southwest. Each El Niño event in the past has resulted in water shortages and drought in some parts of the Pacific (e.g., Papua New Guinea, the Republic of the Marshall Islands, Samoa, Fiji, Tonga and Kiribati), and increased precipitation and flooding in others (e.g. Fiji, Solomon Islands). In El Niño years ocean conditions also change and the western Pacific warm pool expands generally eastwards in the tropical waters. Warm pools on the other hand, contracts slightly westwards in northern equatorial waters. In La Niña years the warm pool is largely constrained to the western tropical Pacific, while expanding slightly to the east in northern equatorial waters.

These oceanic patterns influence primary and secondary productivity in the Pacific and define core habitats of the marine flora and fauna species, including tuna (Mimura, Nurse et al. 2007). With global warming, El Niño events are expected to become more frequent and which will bring increased risks of climate changes and climate variability.

For the Pacific, sea level is expected to rise by between 0.19-0.58 m by the late 21st Century. With sea-level rise increased salt water intrusion into coastal areas is also expected. It will also exacerbate hydro-meteorological effects of climate change and climate variability. In extreme cases, sea-level rise and associated coastal inundation can threaten the very existence of the region's atoll islands, including whole atoll island nations (e.g., Tuvalu and Kiribati). Temperature increases and sea-level rise interact with island topography (coastal low-lying lands, versus steeper inclines) and with the other physical, social, and economic conditions in determining the consequences of extreme climate changes and the islands' vulnerability to them (Bueno et al 2008).

III. Effects of Climate Change and Variability and Sea Level Rise[4]

PICTs, mainly located along the equatorial belt, regularly experience climate and hydro-meteorology-related disasters, including cyclones, high winds, increased rains, floods, droughts and storm surges.

The islands are also vulnerable to climate change because of the sensitivity of their natural ecosystems, economies and livelihoods. The direct and indirect impacts of these disasters on national economies and human livelihoods have been significant, and any increases in frequency and intensities in these events due to climate change will drastically jeopardise the economic potential. The ability of countries to achieve their national development goals, including the Millennium Development Goals (MDGs), will also be compromised due to direct and indirect costs of natural disasters.

Direct costs are usually reported, that is, the costs of damage that occurred during or immediately after a natural hazard event, such as damage to crops and buildings from high winds and flooding. Indirect effects are flow-on impacts that occur over time after a hazard event and are caused by the direct impacts of a disaster, are often not recorded in official disaster records. Amongst indirect effects include water- and vector-borne diseases which increase following prolonged precipitation and flooding.

During the 1950-2004 period cyclones alone accounted for 76 per cent of the reported disaster events, accounting for almost 90 per cent of total direct costs and 79 per cent of fatalities (World Bank 2005). The majority of other natural disasters are accounted for by floods, droughts and storm surges (Table 2 and Figure 1).

Table 2: Reported disasters in the Pacific Islands (1950-2004)

	Number	Reported Fatalities	Population Affected [1]	Reported Losses (in 2004 US$ million)
Windstorms [2]	157	1,380	2,496,808	5,903
Droughts	10	0	629,580	137
Floods	8	40	246,644	95
Earthquakes	17	53	22,254	331
Others [3]	15	274	21,520+	60
Melanesia	110	1,130	2,115,332	1,655
Polynesia	71	494	1,041,012	1,797
Micronesia [4]	26	123	260,662	3,074
Total Pacific	207	1,747	3,417,006	6,526

[1] Fatalities plus total population affected. All data excludes PNG.
[2] Cyclones, tidal surges and storms.
[3] Landslides, tsunamis, volcano eruptions, wild fires and epidemics.
[4] Data for Micronesia is distorted by Guam, which is prone to costly cyclones. EM-DAT considers disasters which are 'situations or events which overwhelm local capacity, necessitating a request to national or international level for external assistance.'

Source: World Bank 2006 citing data from: EM-DAT: the OFDA/CRED International Disaster Database for 1950-2004 data and adjusted by SOPAC (2005) for 1994-2005 data.

[4] From here on, the term climate change is used to refer to climate change, climate variability and sea-level rise.

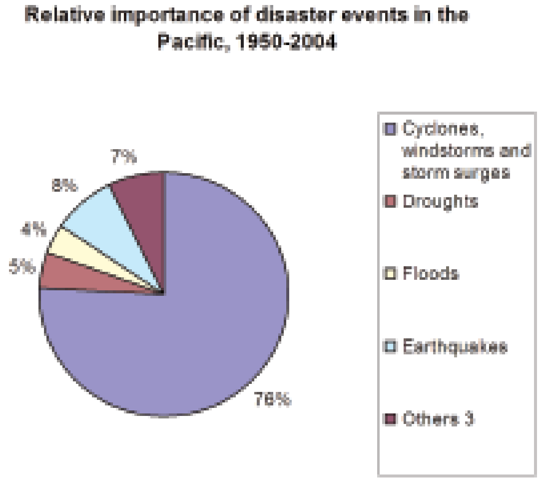


Figure 1: Relative importance of disaster events in the Pacific, 1995-2004

The economic costs of climate change will manifest themselves through the effects of climate change and variability on natural ecosystems, physical infrastructure and human capital that support lives and livelihoods of the people. Climate change will affect coastal ecosystems, including coral reefs, mangroves and coastal foreshore, terrestrial and marine biodiversity, oceanic ecosystems, and freshwater resources. Such changes in the different ecosystems can affect the ecological integrity and supply of goods and services that support human livelihood and wellbeing. Increased temperatures, for example, will directly affect crop yields and the range of crops that can be grown at different elevation. It will also affect coastal currents and processes, migration pattern of tuna fish and influence coral bleaching. Such effects on terrestrial and marine systems will therefore significantly affect the value of subsistence, artisanal and commercial agriculture and fisheries, and thus individual, household, and community livelihoods.

Similarly, changes in precipitation and extreme events, such as floods and drought will affect subsistence and commercial agriculture and food security as well as physical infrastructure important in the market chain. Floods could affect the incidence of water- and vector-borne diseases and human health. On the other hand, increased temperatures and increased humidity due to increased rainfall can also raise the incidence of heat strokes, asthma and other respired illnesses, affecting human productivity.

All aspects of life in the Pacific are expected to be affected, and in extreme cases, human security and even the survival of nation states will be in jeopardy. The impacts will be experienced at all levels, causing direct and indirect economic costs on the general welfare of the people (Figure 2).

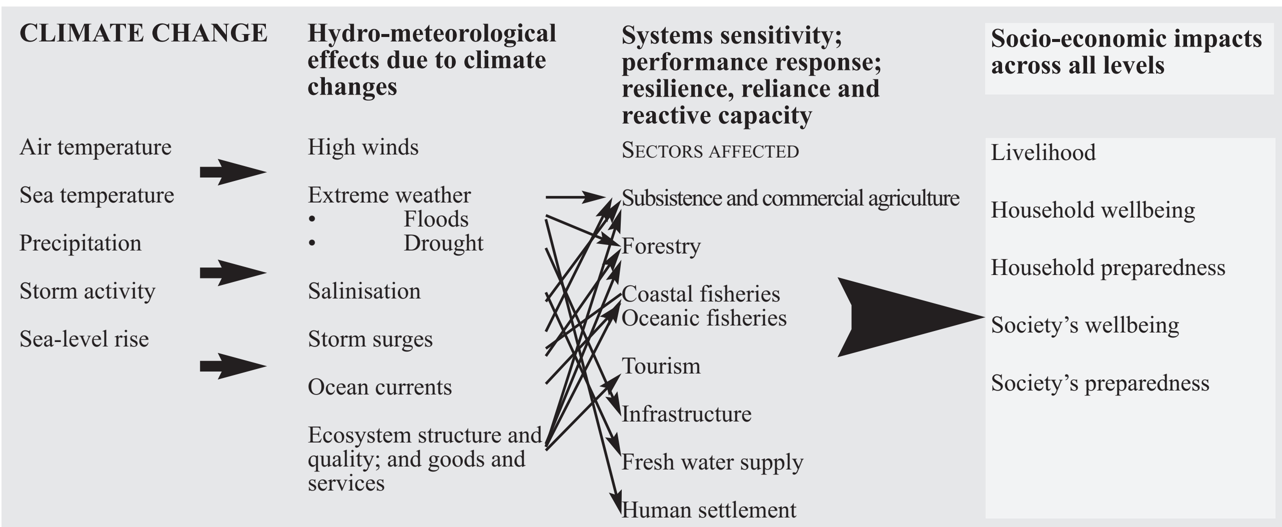


Figure 2: Climate change, its effects and pathway through which socio-economics impacts will be realised

IV. Economic Cost of Climate Change

There is general agreement that recent changes in climate are human-induced, and the general direction of impacts on climate conditions is clear, although there is a considerable level of uncertainty surrounding the link and connectivity between climate, ecosystems, economic subsystems and social effects (e.g. Stern 2007; Benson and Cay 2004). Economic impact of climate change is the interaction between four sets of factors – climatic, ecosystem, economic and social.

To understand the economic costs of climate change, three sets of knowledge are useful:

- 'A' – scientific (i.e. the meteorological understanding of the effects of green house gas emissions, global warming, and its effects on rainfall and temperature pattern, sea-level rise, and oceanic patterns).
- 'B' – direct and indirect impacts (i.e. hydro-meteorological changes on ecosystems, infrastructure and human capital; and
- 'C' – economic impacts (i.e. changes in the economic value on human livelihoods and government finances). (This is summarised in Figure 3).

For the Pacific, the magnitudes, timing, and distribution of climate change impacts are difficult to predict because of uncertainties associated with each key step along the climate change-socioeconomic impact chain, as summarised in Figure 4. There are uncertainties, similar to those found elsewhere to some extent (Stern 2007), for example:

- future GHG emissions levels;
- dynamics of the climate changes at the global and regional level and for each country;
- dynamics and geographic spread of the effects of climate changes and sea-level rise and hydro-meteorological and ocean conditions;
- size and severity of the effects of changes in climatic and ocean conditions on different ecosystem systems and associated goods and services and infrastructure on which various economic activities dependent; and
- size and severity of changes in economic activities on household income and livelihoods, as well as social wellbeing, including national finances.

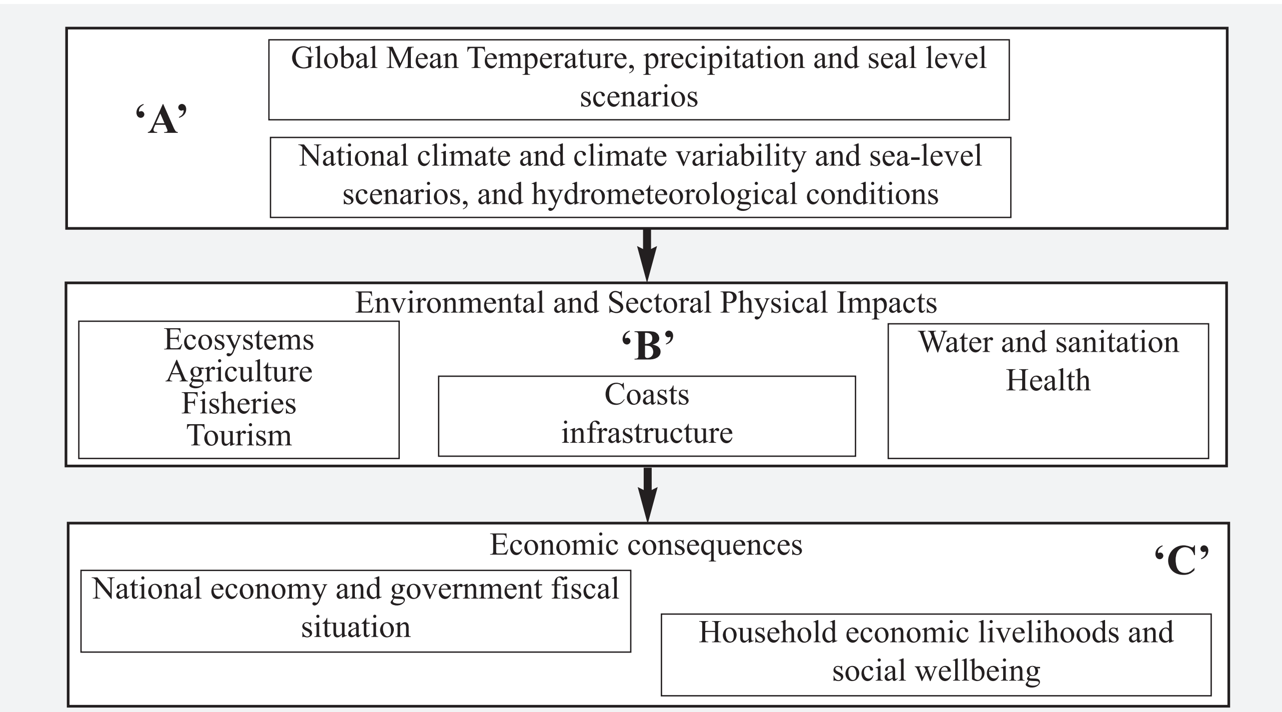


Figure 3: Understanding of key linked components needed before economic impact of climate change can be assessed

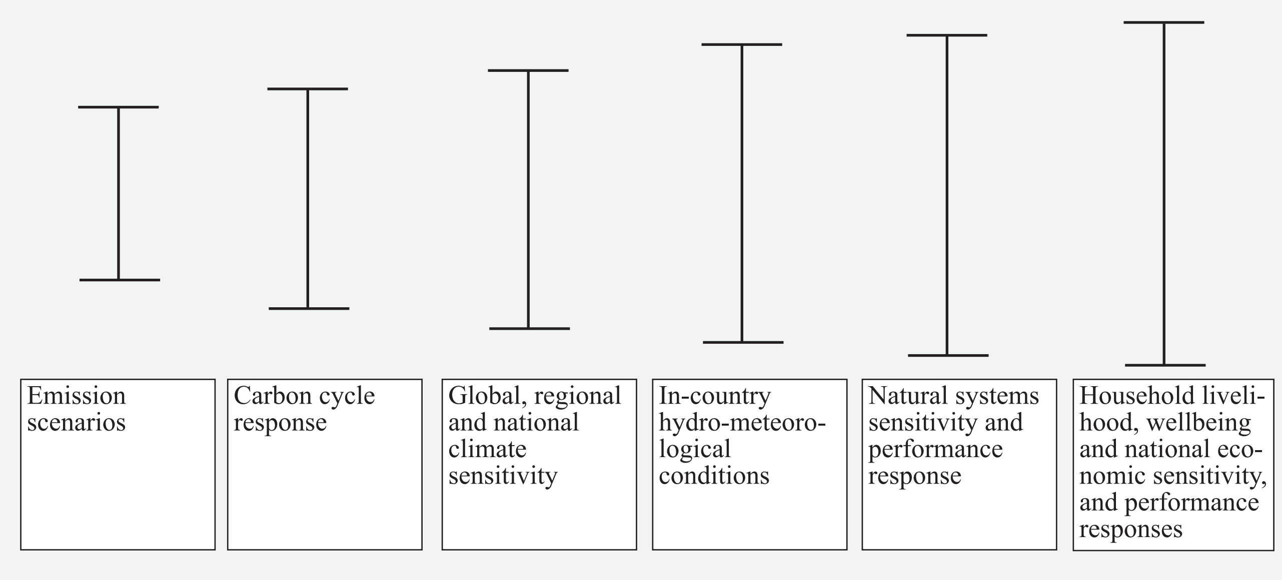


Figure 4: Cascade of uncertainties associated with global-regional-nation climate responses and national, sectoral and household wellbeing impacts

Methodology

Scientific models based on theoretical understanding and their validation using historic data, are generally used to reduce the level of uncertainties associated with predictions, particularly where robust empirical scientific and economic information is unavailable. These were summarised in the IPCC Working Group II's report. For the Pacific, a limited number of climate models are available and there is also limited quantitative or empirical scientific information. Country-specific information is very limited at best, and almost non-existent for individual countries. Economic cost predictions of the effects of climate change based on rigorous quantitative assessment are even fewer.

Only a few studies in the Pacific have directly addressed climate change impacts, although relatively more studies have been undertaken on the economic cost of past natural disasters, including climate-related disasters. These studies have adopted commonly used economic impact assessment methods, using past disaster events to either validate impact models or make projections about costs of future events.

Two categories of impact assessment approaches are generally used (Stern 2007):

- disaggregated techniques (i.e. considering the physical impacts of climate related and other natural disasters on the economy, on human life and on the environment); and
- economic models, including integrated sector-level assessment models.

In all cases, a 'with and without' disaster-based analysis is used (e.g. World Bank 2004; McKenzie et al 2006, Holland 2008). 'With and without' analysis involves determining economic values of ecosystems, vulnerable sectors, and household livelihood under the scenario 'without disaster', and 'with disaster'. The difference then is attributable to the effect of that particular disaster, allowing for the consideration of the changes in the economy due to other factors as well.

Climate change-related economic cost assessment methods vary between studies and even within a study. Generally, either individually or in some combination four methods – modelling, empirical judgment, expert judgment and anecdotal information – have been used. Depending on the aspect of climate change impacts under consideration, the approach adopted and the availability of context-specific scientific, economic and social information different levels of quantitative estimates have been produced in the Pacific:

- Quantitative economic estimates (e.g. World Bank 2000; Shorten et al. 2003)), covering all three subcategories of empirical analysis, 'A', 'B' and 'C' summarised in Figure 3;
- Qualitative economic impact 'assessment' based on rigorous context specific scientific

assessment of climate change ('A' in Figure 3), and limited impact assessment ('B' in Figure 3)(e.g. Nunn et al. 1994; Koshy 2007)); and

- General qualitative commentary on the nature of climate impacts on economic activity and people, using predicted climate change scenarios of IPCC and general country specific environmental, economic and social characteristics knowledge (e.g. Hay and McGregor (1994); Sem and Underhill (1994); Reti (2008)).

Quantitative assessment

National economic cost estimates are usually determined as a sum of sector-based 'business as usual' scenario and climate change predictions data from regional and global modelling available from IPCC. Habitat/ecosystem based 'business as usual' calculations are made using baseline scientific information on 'goods and services' supported by specific ecosystems, such as coral or mangroves, survey-based economic value data or average values obtained from the literature. At times, expert knowledge is also used to help define the functional relationship between climate change and sector level impacts. In some cases, replacement costs of infrastructure or rehabilitation costs adopted by insurance industry, or opportunity cost of foregone services are also used. When all else fails, a 'cost transfer' method is adopted using aggregate costs associated with past natural disasters in other countries and regions are applied to the Pacific.

The World Bank (2000), for example, examined the potential effects of climate change in a high island, Viti Levu in Fiji, and an atoll island, Tarawa, Kiribati, using an integrated assessment model, the Pacific Climate Change Impacts Model (PACCLIM). (PACCLIM is a precursor of the SimCLIM model developed by CLIMSYSTEM (see box).) This modelling was complemented with sector level impact models, population projections and baseline historical climate records.

Box 1: SimCLIM

SimCLIM is computer simulation decision-support model that links and integrates data and model for climate impact and adaptation assessments. SimCLIM can be used to support decision-making with its capacity to:

- Describe current climate conditions
- Examine current climate variability
- Assess risks – present and future
- Investigate adaptation – present and future
- Create climate change scenarios
- Conduct sensitivity analyses
- Examine sectoral impacts , such as coastal erosion or flooding
- Examine risks and uncertainties
- Facilitate integrated impact analyses

The user can define the spatial scale of analysis from regional to local. The custom-built geographic information system (GIS) supports both spatial and statistical analysis methods for exploring extreme events and estimating return periods. Country specific SimCLIM currently exists for Australia and New Zealand and Fiji. Vanuatu recently (September 2008) purchased SimCLIM software for their use.

Source: CLIMSYSTEMS: http://www.climsystems.com/pluto/simclim/; www.ami.ac.cn/C5/Presentations/QianDao%20Lake/Thursday_lu2.ppt

Where empirical information was not available, the World Bank used qualitative observations and expert judgments. The study undertook country and context-specific economic analysis of the potential sectoral impact of climate change. It used enhanced PACCLIM generated scenarios of temperature, rainfall pattern, sea level rise and changes in cyclones and ENSO events. Economic cost estimates were based on actual field surveys, expert judgments and 'cost transfer' from other parts of the regional or world. Empirical estimates of economic impact of climate change on four sectors: coastal areas, water resources, agriculture and tourism, are summarised in Table 3.

Table 3: Summary of Estimated Annual Economic Impact of Climate) Change on the Coast of Viti Levu, Fiji, 2050 (millions of 1998 USD)

Category	*Annual damages (USD million)*
Impact on coastal assets:	
• ***Costs due to*** Loss of land to erosion	2.9-5.8
• Inundation of land (including agriculture) and infrastructure	0.3-0.5
Impact on coral reefs - Cost of Economic Loss associated with:	
• Subsistence fisheries	0.1-2.0
• Commercial coastal fisheries	0.0.5-0.8
Tourism	4.8-10.8
Habitat	0.2-0.5
Biodiversity	*
Nonuse values	*
Impact on mangroves	*
Impact on seagrass	*
Total estimated damages	8.4-20.4

* Likely to have economic costs, but impact not quantified.
a Accounted for in the erosion analysis.
Source: Background reports to the World Bank Report 2000.

The only other climate change-related economic analysis known to be completed in the Pacific adopted a modelling approach, supported by potential insurance related damages measures in Vanuatu (Shorten et al. 2003). This study used past cyclones, particularly Cyclone Uma, to make predictions about precipitation and wind speed for future cyclonic events of various intensities. These were combined with geo-referenced local surveys of villagers and households, urban building and infrastructure, and geographic information system (GIS) based analysis to develop potential average damage costs for the coastal zone, over different cyclone intensities.

Infrastructure replacement costs approaches have been used in several other studies to determine economic costs associated with recent climate related natural disasters. Woodruff (2007), for example, adopted infrastructure replacement costs approach, and used context specific socioeconomic information and infrastructure characteristics, to estimate the economic costs of different degrees of flooding events in Samoa (Woodruff 2007). Holland, on the other hand, estimated economic cost of recent 1-in-a-100 year flooding event in Navua, Fiji to determine the economics benefits and costs of adopting a flood warning system (Holland 2008 (in press)).

Qualitative economic assessment based on quantitative scientific assessment

Semi-empirical approaches have also been used to make projections of ‘socio-economic’ impacts, using climate models. Models such as SimCLIM, and its predecessor VANCLIM, were used to generate context-specific predictions of key climate variables – temperature, rainfall, sea-level rise, wind speed and storm heights (e.g. Nunn et al. 1994; Koshy 2007). Nunn used the results of PACLIM together with inundation models and storm surge models to determine respective expected physical damage function in Fiji and Samoa under different climate change scenarios (e.g. Nunn et al. 1994a; Nunn et al. 1994b). Spatially referenced descriptive socio-economic characteristics were produced using field surveys alone, (for example for Navua river basin (Koshy, 2007)) and a combined field survey, GIS and expert opinions (for example, coastal areas in Natodola Bay (Koshy, 2007)); Yasawa Islands (Nunn et al. 1994a) and Savaii, Samoa (Nunn et al. 1994b).

Such model simulations and other information were then used to draw conclusions about the scale and extent of damage expected under different inundation scenarios on things such as infrastructure, agriculture, and coastal land. Unfortunately, many of these studies fell short of undertaking proper ‘with and without’ analysis, including economic analysis. Nor did these studies include economic models or empirical economic cost assessment. These studies produced some valuable insights into the nature of climate change-related impacts and made general comments on the socioeconomic implications of climate change (see Box 2). In some cases, fairly detailed scientific assessment was undertaken to understand possible causes of recent observed changes in the coastal landscape (e.g. in Tuvalu and Kiribati (Webb, 2006)). These studies adopted scientifically robust GIS-based methodologies, aerial photographs and satellite imagery to determine recent changes in coastal landscape. Field visits and local knowledge were used to check (ground truth) the findings, before generalised policy recommendations were made. Such studies could be extended to include climate change modelling to predict future coastal scenarios under climate change. When combined with 'with and without' analysis, potential economic impact of climate change could also be estimated.

Box 2: Type of qualitative conclusions drawn in some studies

> The net flooding impact experienced by the residents on their homes will depend on adaptive measures taken, such as building sturdy and raised homes, and shifting to less flood-prone areas within Navua. However, the full social and economic impacts of previous floods (which were beyond the scope of this paper) are currently unknown.
>
> However, their impacts are deemed substantial, taking into consideration, destruction of root crops, loss of income and properties, diseases, and in some cases, death. Areas … are unstable and the shoreline will continue to change over time for many years to come. It was agreed that it would be better to use their time, effort, and money to rebuild important buildings, on the high safe grounds and not to rebuild seawalls.
>
> Source: Koshy (2007) and Mataki (2006)

In other studies (McKenzie et al. 2005; Woodruff 2007; Holland 2008) economic costs associated with recent climate-related disasters are estimated. While they do not (nor were set out to) make any projections about potential effects of climate change expected under expected scenarios of climate change and climate variability, the results could be extended to such analysis. For example, if such economic analyses were conducted together with scientific modelling exercises, such as those carried out in the Pacific, for example by Nunn et al 2003; Koshy 2007; Webb 2006, economic cost assessment of future climate change predictions could have also been possible. Such a programmatic approach, covering scientific modelling and 'with and without' economic analyses, was adopted by the World Bank 2000; and Shorten et al 2003.

Qualitative commentary

By far the most common approach adopted in the Pacific is based on the use of country specific environmental, social and economic characteristics and IPCC's global or regional projections on climate change and variability and sea-level rise to draw some general remarks about the nature of potential impacts of climate change on human livelihoods and well being (e.g. Hay and McGregor 1994; Prasad and Manner 1994; Sem and Underhill 1994; Falkland 1999; Hay et al. 2003; SPREP nd). Included in such qualitative assessments are the community vulnerability assessments carried out for the Canadian-funded Community Building for the Development of Adaptation Measures in the Pacific Island Countries (CBDAMPIC) in Vanuatu (SPREP nd), Cook Islands (Carruthers and Bishop 2003), Samoa (SPREP nd) and Fiji. Under the CIDA project, community-based assessments involved stakeholders adopting participatory approach to assess their own current adaptive capacity; assess expected future changes in hazard exposure, assess own adaptive capacity; and identify adaptive strategies. In the CIDA projects, analysis was largely qualitative with many of the expected changes in country 'assumed' to be climate related.

The above discussion emphasises that many disaster impact assessments have suffered from poor information and limited capacity, as also noted by McKenzie et al 2005 (see Box 3). This would, no doubt, also affect future efforts to undertake impact assessments of climate change, particularly since past disaster impact assessments are used, as discussed earlier, to either validate climate change models or used to predict future costs under changed climate scenarios. The literature review also demonstrates that without rigorous economic costs analysis based on a holistic and integrated approach, only partial understanding of the economic costs is possible. Information gaps thus need to be urgently addressed and efforts made to at least develop based-line information related to key hazard areas, including geo-referenced socio-economic information and their sensitivities to natural disasters.

Box 3: Impact Assessment Practices in the Pacific

Assessments of the impacts of natural disasters in the Pacific are often very narrow and limited in scope even for major natural disasters such as cyclones, volcanic eruptions and earthquakes. For small-scale disasters, assessments are made on an ad hoc basis. Assessments of disaster impacts typically only focus on quantifying immediate direct damages, such as deaths and injuries, and damage to buildings, subsistence and commercial crops, and economic and social infrastructure. Impacts on the private sector are frequently ignored. Assessments are usually conducted immediately following the disaster to prioritise relief and rehabilitation needs. Evaluations of indirect costs and environmental, social and psychological impacts of natural disasters are rare in the Pacific. Occasional reassessments are made of major natural disasters to estimate longer-term impacts, but this is not done on a systematic basis. Assessments of disaster impacts on social sectors, such as health and education, tend to focus on the immediate damage to infrastructure, without assessing the long-term impact on health and education indicators such as disease outbreaks and school attendance rates. Where indirect and long-term impacts of disasters are considered, they are usually quantified rather than valued in monetary terms. Valuation of direct damage is typically limited to estimating the monetary cost of rehabilitation of damaged buildings, subsistence and commercial crops, and economic and social infrastructure. Some assessments of declines in rural economies following a natural disaster have been conducted but on an ad hoc basis. Damage assessments in the Pacific typically involve collaboration among a wide range of contributors.

Source: McKenzie et al. (2005)

Recommendation 1: *Adopt an integrated analytical approach to determine the economic costs of climate change and variability, which also includes rigorous scientific modelling, sensitivity assessment as well as 'with and without' economic cost analyses.*

Economic Costs of Climate Change – national

Empirical estimation of the economic costs of climate change in the Pacific is very limited. Recent studies (e.g. World Bank 2000; World Bank 2005; SOPAC 2005) suggest that PICTs on average experience natural disaster-related costs of about 2-7 per cent of their national GDPs, although in specific natural disaster years the costs can be higher. In monetary terms, costs to the PICTs since 1950s has been in the order of about US$2.8 billion, with Melanesian countries, because of their geographical location, generally suffering the largest number of disaster events and experiencing large impacts on people and economy. Smaller countries, such as Tonga and Samoa, face relatively fewer disaster events, but experience higher economic and social shocks relative to their small economies.

The nature and extent of economy-wide impacts depend on a complex set of influences, including the nature of hazard, the state of individual wellbeing, local and national economic structure and the economic policy environment (Benson and Clay 2004). Vanuatu, for example, during past natural disaster years suffered on average economic losses of 30 per cent of its nominal annual GDP, or about Vatu 300 billion (Table 4). These estimates are based on past natural disaster events and do not reflect any consideration of recent trends in climate change. Under a worst case scenario of future cyclone events, the World Bank has estimated a cost of AU$260 million could be expected for Vanuatu, which is about 130 per cent of their recent 30-year average real GDP of AU$195 million (World Bank 2005).

Table 4: Disaster overview for Vanuatu, 1975-2004

Total Number of cyclones, 1975-2004	41
Number of cyclones with costs	11
Total costs – constant 1983$	Vatu 3225 million
Average costs in disaster years (Constant 1983$)	Vatu 293 million
Average costs in all years	Vatu 79 million
Average GDP in real terms	Vatu 14,180 million
Average GDP in AUD	AU$ 195 million
Average cost in disaster years as % of GDP	23%
Maximum cost	AU$ 153 million

Source: Estimated using data from www.adb.org/statistics; Global Disaster Database http://www.emdat.be/

Individual disaster events can have devastating impacts, although in comparison with global or regional experiences, they may appear to be small (AusAID 2005). Cyclone Ivy in Vanuatu for example, caused a total economic loss of Vatu 1,345 million (or US$12 million), but it affected almost a quarter (50,000) of the population, and caused one fatality. On the other hand, at the sector level, Ivy affected 90 per cent of water resources, 70 per cent of roads, 60 per cent of health infrastructure, and over 80 per cent of food crops. Similar examples can also be found in other countries such as Fiji, where a recent major cyclone Ami (2002) caused severe flooding and losses in key development sectors: housing, education, health, agriculture, tourism, sugar, business, infrastructure, telecommunications and power supply with an estimated cost of damage at FJ$66 million (or US$32 million). Over 70 per cent of this damage was to the public sector. Similar climate change-related costs estimates have been derived.

It is estimated that similar, if not higher impacts, are expected in the future as well. For example, the World Bank estimated that high islands, such as Viti Levu in Fiji, could experience average annual economic losses of US$23-52 million from climate change, equivalent to 2-4 per cent of Fiji's GDP. On the other hand, a low group of islands, such as the Tarawa atoll in Kiribati, could face average annual damage from climate change of US$8-16 million, as compared to a GDP of US$D47 million. These costs are likely to be considerably higher in years of extreme weather events (World Bank 2000).

Economic costs of climate change is a function of the status of current economic activities, including infrastructure. A highly developed area were affected by climate change impacts could be more significant compared to an area with low level of economic activity. Computer modelling of extreme weather events, for example, in the capital cities of Fiji, the Solomon Islands, Vanuatu, Samoa and Tonga, predicts that potential infrastructure losses alone could cause damage of up to 60 per cent of GDP in the event of a 1-in-100 year cyclone, as compared to for example an average of 2-4 per cent of GDP across the region (World Bank 2000).

Pacific costs in comparison to global economic costs

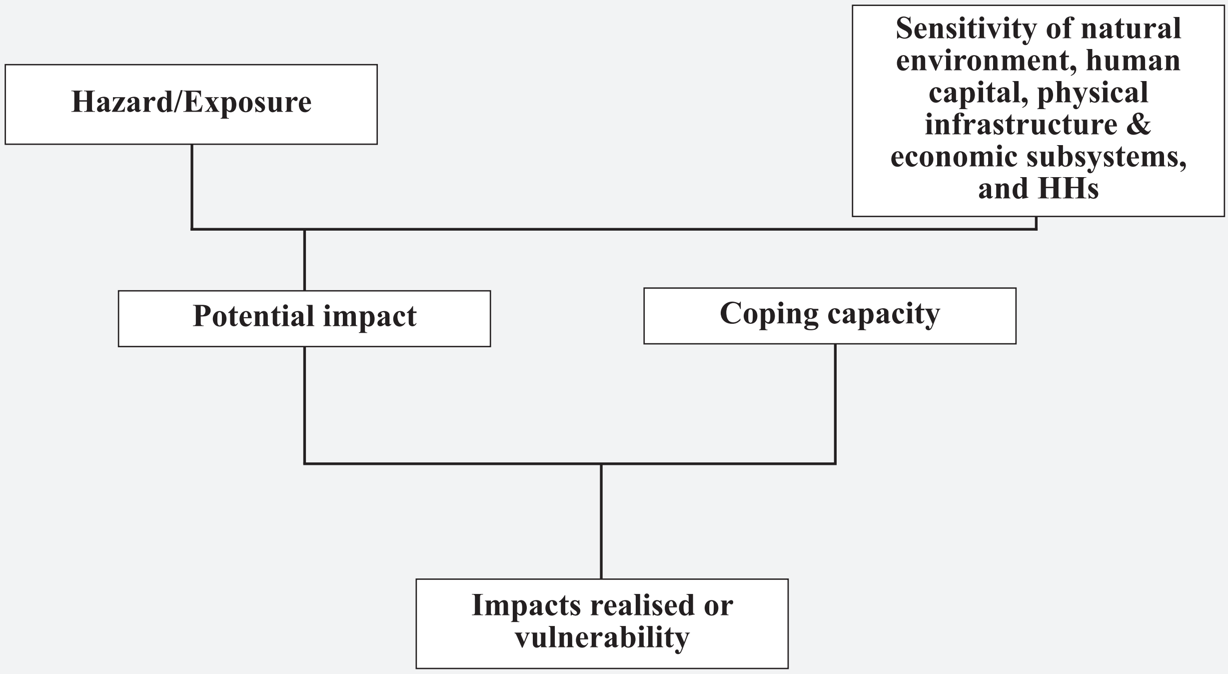
The 2006 Stern Review, which undertook a comprehensive economic analysis of the economic impacts of climate change and the costs of mitigation at the global level. It is thus reported that:

- the cost of the impacts of climate change to be between 5-20 per cent of global GDP;
- extreme weather could reduce global gross domestic product (GDP) by up to 1 per cent;
- a 2°-3°C rise in temperatures could reduce global economic output by three per cent, if, however, temperatures were to rise by 5°C, up to 10 per cent of global output could be lost;
- the poorest countries would lose more than 10 per cent of their output; and
- worst-case scenario global consumption per head would fall by 20 per cent.

Where the Pacific region differs from these predictions is in the area of flow-on impacts of natural disasters, and the particular vulnerability of the people and economies to potential effects of climate change, because of their unique social, economic and political predicaments.

Flow-on (indirect) economic costs
The real total national economic impact of climate change is likely to be much larger than the national level direct economic costs estimates suggest. One of the reasons for this is that many of the above studies focus on immediate impacts, which by default means direct and tangible effects. Indirect and secondary impacts can be equally, if not more, important than the national economic indicators suggest. Indirect impacts tend to affect basic conditions of human livelihoods over a much longer period than the direct impacts. Such indirect impacts also would affect a nation's financial capital required to support people's needs and aspirations.

As Schoeter (2004) argues, the nature and degree of economic costs of climate change impact depends on not only the nature of exposure to hazard but also the sensitivity of the environmental and economic subsystems, which support different sectors, and the coping capacity of individuals, households, communities and the state (Figure 5). Sensitivity can be seen from the perspective of individuals, communities and states. At the household level this can be further divided into things such as food sensitivity, livelihood sensitivity, and coping capacity (Table 5).



Source: Adapted from Schroter and Consortium (2004)

Figure 5: Factors determining vulnerability to climate change

Table 5: Types of sensitivities and determinants of coping capacity

Sensitivity	Determinant of the coping capacity
Ecosystem sensitivity	Diversity in Economic Activity
Food sensitivity	Human Resource Capacity
Livelihood sensitivity	Governance/Institutional Capacity
Settlements/Infrastructure Sensitivity	Technological Capacity
Human health sensitivity	Financial Capacity
Source: Adapted from Cameron (2008)	

Macroeconomic impacts

Climate change effects will undoubtedly affect national macroeconomic and the national fiscal environment (Benson and Clay 2004). These include:

higher government expenditure and/or partial reallocation of already committed financial resources (usually from the capital budget), to meet both the costs of repair and rehabilitation of public property, and to provide support to victims;
a fall in government revenue as lower levels of economic activity, including possible net falls in imports and exports, imply reduced direct and indirect tax revenue; and
increasing budgetary pressures, which may result in governments borrowing more, placing inflationary pressures on the economy.

International modelling suggests that disasters can dampen investment and reduce long-term economic growth through their negative effect on countries' credit rating and an increase in interest rate on external borrowing (Cochran 1994) and budgetary pressures, quoted in Benson and Cay 2004). Regression analysis of past macroeconomic performance against key factors, including natural disaster events, in small island developing states confirm that disasters such as cyclones have short-to-medium term negative impacts on national GDPs and on poverty levels. Comparative cross-sectional data on real GDP performance for 115 countries over a 34-year period also suggest that "countries experiencing a higher incidence of natural disasters tended to achieve lower rates of growth than countries that experienced lower incidence to disasters" (Benson 2003 quoted in Benson and Clay 2004). A similar conclusion was also arrived at by Benson for Fiji (Benson 1997).

National sensitivities and flow-on effects depend on the structure of the economy. Globally, it is also found that the negative effects of disasters on national GDP were relatively less severe for countries with low reliance on the primary sectors (Benson 1997; Benson and Clay 2004). PICTs are heavily dependent on primary sectors, such as agriculture, forestry, fisheries and tourism for their economic development (Table 6). These sectors are also highly sensitive to climate change.

Table 6: Main Economic Activities of selected PICs

Country	Main Economic activities	Share of GDP (%)		
		Primary Sector[a]	Manufacturing	Tertiary Sector[b]
Melanesia				
Fiji	Sugar, Tourism, Copra, Gold, Silver, Clothing, Timber, Fish processing, Cottage industries.	23 (1996)	15 (1996)	62 996)
PNG	Copra crushing, Palm oil processing, Plywood production, Wood chip production, Mining of gold, silver, and copper, Crude oil production, Construction, Tourism, Timber, Coffee, Cocoa, Seafood.	54 (1995-6)	8 (1995-6)	38 (1995-6)
Solomon Is.	Timber, Fish, Palm oil, Cocoa, Copra	23.4 (1996)	N/A	N/A
Vanuatu	Fishing, Offshore financial services, Tourism, Food and fish freezing, Wood processing, Meat canning; Coconuts, Cocoa, Coffee.	N/A	N/A	N/A
Polynesia				
Cook Islands	Fruit-processing, Tourism, Finance, Copra, Citrus fruits, Clothing, Coffee, Fish, Pearls and pearl shells, Mining, Handicrafts.	18.8 (1995)	2.7 (1995)	78.5 (1995)
Samoa	Fishing, Tourism, Timber, Food processing, Coconut oil and cream, Copra, Beer	N/A	N/A	N/A
Tonga	Tourism, Fishing, Squash, Fish, Vanilla, Root crops, Coconut oil	N/A	N/A	N/A
Tuvalu	Fishing, Tourism, Copra; Stamps/coins.	N/A	N/A	N/A
Kiribati	Fishing, Handicrafts, Copra	39.9 (1992)	10.8 (1992	49.3 (1992)
Nauru	Phosphate mining, Financial services, Coconut products.	N/A	N/A	N/A
Micronesia				
FSM	Tourism, Construction, Fish processing, Craft items (shell, wood, pearls), Garments, Bananas, Black pepper.	N/A	N/A	N/A
Marshall Islands (the)	Copra, Fish, Tourism, Craft items (shell, wood, pearls), Offshore banking (embryonic), Coconut oil, Trochus shells	N/A	N/A	N/A
Palau	Tourism, Craft items (shell, wood, pearl), Commercial fishing, Agriculture.	24.4 (1996)	0.8 (1996)	74.8 (1996)

a. Primary sector includes agriculture, forestry, fishing and mining
b Tertiary sector includes all services and construction

Source: ADB (2003) from ADB Annual Reports, ABC World Fact Finder, SPC Pocket Statistical Summary (1998).

Reports form Caribbean countries indicate that natural disasters also determined significant shifts in the structure of the economy. In Dominica, for example, the agricultural sector product and agricultural share in GDP fell with each major natural disaster shock. Such a change was explained by a combination of a gradual reduction in large-scale production (because of failure to invest in capital replacement), movement of smallholders into employment and off island-migration (Benson and Clay, 2004).

Such effects will have far-reaching impact on national development efforts, including social development, beyond the natural disaster years. Regression analysis of natural disasters in Fiji for the period 1970-2004, including climate-related cyclones (which accounted for 90 per cent of disasters), suggest a negative relationship between disaster and human development status (Singh, Lal and Holland 2009 (draft)). Human development status, measured in terms of HDI was used as a proxy indicator for vulnerability sensitivity. The HDI index combines normalised measures of life expectancy, literacy, educational attainment and per capita GDP.

Natural disasters are also statistically correlated with the disposable income of households. That is, disasters cause a decrease in expected disposable income. Conversely, the number of people affected by natural disasters is also a function of the development status of the country. The lower the HDI, the greater is the number of people affected by natural disasters. This is consistent with the other reports. Jha (2008), for example, notes that given past incidence of disasters and the associated costs to GDP, countries such as Vanuatu and Fiji are unlikely to grow economically and meet its MDG on poverty.

Thus, while PICTs may be committed to achieving their National Development Goals (NDGs) and MDGs, their achievements so far have been mixed, partly due to the frequent exposure to natural disasters. Climate change effects will further impede national development efforts, and prevent PICTs from achieving their development targets (IPCC 2007). Similar sentiments were also recently expressed at the UN Human Rights Open Consultative Meeting organised by the UN Office of the High Commissioner for Human Rights held on 22 October 2008, when it was noted that MDG 1 (poverty), MDG 2 (education), MDG 7 (environment, in particular target 10 for access to clean water and sanitation) are not likely to be met by 2015.

Economic Costs of Climate Change – Sector level impacts and human livelihoods

Detailed sectoral level economic cost estimates are limited in the Pacific, though the gravity of potential impacts of climate change becomes more apparent when one considers sectoral level impacts, including on human livelihoods. Livelihoods comprise the capabilities, assets and activities required for making a living. Livelihoods are considered to be sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, now and in the future (Carney 1998).

The ability to cope with and recover from external shocks depends on such things as the health of natural resources and ecosystem (natural capital asset), human health (human capital asset), physical infrastructure (physical asset) and financial resources (financial asset) available to people. Although the relationship between these assets and livelihood effects are complex and dynamic, they do determine the sensitivity of individuals, households and communities to cope with, and recover from, climate and other natural disasters. Conversely, sectoral level effects of climate change will affect thee value and quality of these assets, and which in turn will determine the vulnerability and resilience of people to natural disasters in the future.

The following discussion examines the effects of climate change on a selected number of primary sectors – agriculture, fisheries, and tourism, and core natural ecosystems and resources – coral reefs, mangroves and water. For the Pacific peoples these sectors and resources are central to their livelihood and wellbeing, which are also highly sensitive to the effects of climate change.

Primary Sectors

Agriculture, and other primary sectors, is an important source of livelihood for the people in the Pacific. Subsistence and commercial activities in these sectors contribute on average between 20 and 54 per cent of the national GDPs (Table 5). These sectors are, as noted earlier, also highly sensitive to the effects of climate change, and which will manifest through several different pathways.

Agriculture

For the agriculture sector, the negative effects of climate change will be realised through changes in temperature and rainfall patterns as well as sea level rise. These are expected to have multiple impacts on subsistence and commercial agriculture (Figure 6).

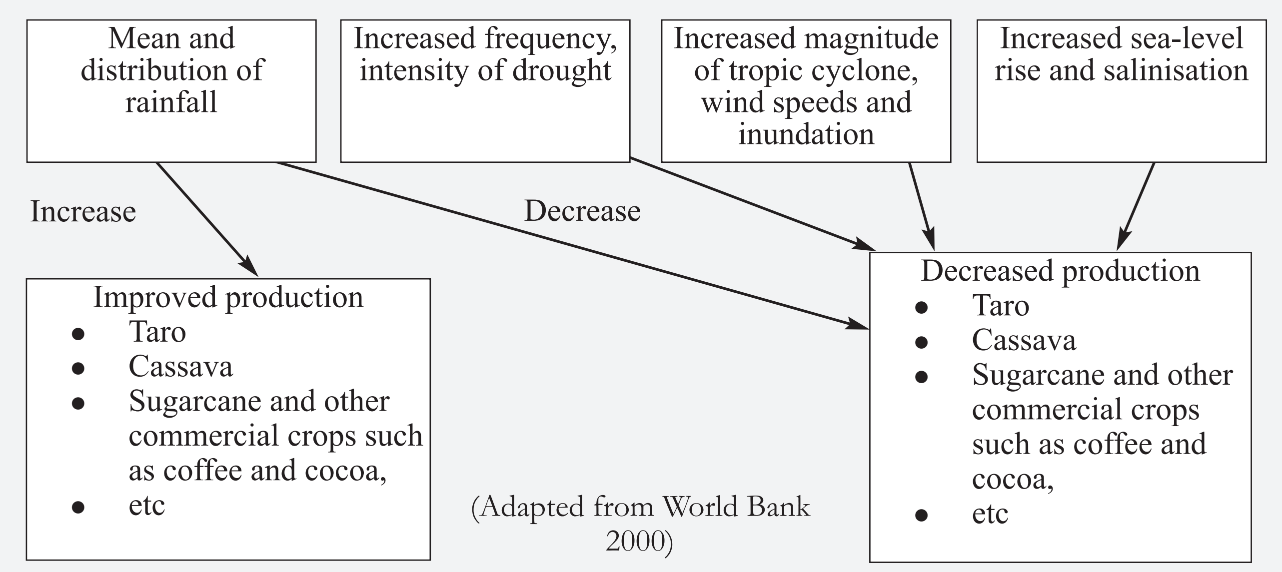


Figure 6: Climate change effects and pathways of manifestation of impact on the subsistence and commercial agriculture

The effects of climate change will vary depending on sensitivity of the local situation and the tolerance of local crops to changes in climatic conditions. Some fruits, such as pineapple, have better capacity to cope with hot conditions (Hay et al. 2003) than other crops, such as sugarcane. On the other hand, climate change will, in some cases, affect the distribution of crops, with some crops seen to move up few degrees in altitude due to global warming. Even with fruits and other products harvested from the wild, there is evidence to suggest that some of the indigenous plants can expect to see a change in flowering and fruiting patterns (Box 4).

Box 4: Changes in flowering and fruiting patterns in PNG and the Solomon Islands

Communities in the Temotu province of Solomon Islands, for example, have witnessed changes in the fruiting patterns of breadfruit affecting traditional nambo production – a product of significant importance for food security for rural communities (Mike Bourke, pers comm. August 2008). In PNG, too, crops such as coconuts, mango, betel nut and breadfruit are now observed in higher altitudes than before Source: Allen and Bourke (2008).

Changes in variability and extreme temperature, rainfall and droughts effects will also change the types and incidence of plant and animal pests and diseases, threatening agricultural production and increasing the risk of transboundary and zoonotic diseases. Livestock diseases are also expected to be affected, with particular significance to countries, such as Vanuatu which rely heavily upon beef export for their much needed foreign exchange.

Increased frequency and severity of tropical cyclones and drought are likely to lead to an increase in crop losses. To the extent that rainfall increases manifest themselves as extreme events, flood risk is also likely to increase agricultural losses. The absolute magnitude of impacts will, no doubt, also depend on the scale and value of current economic activities in the country.

In Fiji, the World Bank (2004) estimated expected agricultural costs of US$13.8-14.2 million for Viti Levu, under the expected climate change and climate variability scenarios expected by 2050[5]. This is equivalent

[5] These estimates were based on expected loss of production and change on major economic activities based on sugarcane, dalo, cassava, and sugarcane. These cost estimates were based on past reductions in sugar cane production during drought in the El Nino year 1998/99, and projected to 2050. Where detailed crop data was not available, crop model such as PLANT-GRO, was used for non-sugarcane crops.

to a reduction in agricultural production by 26 per cent and a decline in the national GDP by 1.3 per cent. McKenzie et al. (2005) estimated large direct and indirect agricultural loss associated with Cyclone Ami in 2003 was equivalent to about FJ$66 million.

In the future such effects on the agricultural sector could be much higher, as the projections by IPCC (AR4) suggest that the Pacific islands could expect to see, with moderate level of certainty, an increase in the wind speeds of 0-20 per cent, even if there are no expected changes to the frequency of cyclones (though modelling results give conflicting projection). Under such a scenario, the expected agricultural impacts in Fiji could be as high as FJ$80 million.

Sea-level rise

Indirect effects of increased inundation of sea water in coastal areas could lead to the temporary loss of productive areas and with the deterioration in soil quality. Atoll islands and low-lying areas are, in particular, highly vulnerable to sea-level rise, because of the limited availability of agricultural land and limited freshwater supply. Where sea-level rise causes permanent damage to agricultural land, longer term consequences could affect people's basic survival and ability to continue to reside in their home land. In places like Bougainville, PNG and Tengua in Vanuatu, communities have had to relocate because of the effect of salt intrusion on their gardens (See Box 5).

Box 5: Impact of sea-level rise and resettlement of Carteret Island, Bougainville

This sea level around the Carteret Island, which is an atoll island of the Autonomous Region of Bougainville, Papua New Guinea, has risen 10cm in the past 20 years, inundating plantations. With salt water intrusion, many of the food crops are difficult to grow. The number of breadfruits produced per tree has decreased, compared to what was produced 30 years ago, and the fruits are getting smaller in size. Similarly bananas have been reported to be struggling to grow in the salt-inundated land. Many of the 1500 residents had run out of food and their staple, coconuts, are being wiped out as the sea level rises. Food gardens and coconut groves had been destroyed and children were going to school hungry. It is extremely difficult now for food crops to grow on the atolls. The situation had deteriorated to the point where the community needed to be relocated to higher ground. They have become the world's first climate change refugees.

Source: Ursula Rakova, chief executive officer of Tulele Peisa, a local NGO advocating for the rights of islanders, told IRIN. (UNOCHA, 8 June 2008) http://www.irinnews.org/report.aspx?ReportID=78630

More commonly, storm surges and increased salt-water intrusion would limit crops that could be grown, and exacerbate existing threats to food security. The intrusion of saltwater into freshwater lenses could also result in severe reductions in several subsistence crops, including taro (Wilkinson and Buddemeier 1994; Watson et al. 1998), breadfruit, coconuts (Lobban and Schefter 1997), and sugarcane (Nunn 1997) as well as lowland forests (SPREP 1999). However, in some cases, interpreting such changes some caution is warranted, particularly when attributing observed changes to a particular cause, such as climate change (see Box 6). As noted by Webb 2007, observed changes in crop distribution and performance may also be due to other forces at play.

Box 6: Salinisation of taro pits, and climate change effects.

Throughout the central Pacific atoll islands, swamp taro, *Cyrtosperma chamissonis*, is considered to be tolerant of saline ground conditions; taro has an upper limit of salt (conductivity) tolerance of < = 2500 micro S/cm. While conductivity measures in Niutao, Tuvalu, showed salinity levels to be beyond the natural range of saline conditions. While it is possible that increased salinity could have arisen due to sea-level rise, there is anecdotal evidence that suggests that engineering may have contributed to the salinity issue. (Webb 2007)

Livelihoods and agricultural impact
Climate change could affect basic food security as well as income security. Food security is defined as a situation when a household or community has sufficient subsistence food of their own or has sufficient income to purchase the food they need.

Agriculture is an important source of food security, particularly for rural communities, although there is a large variation. The value of subsistence farming far exceeds the value of commercial production throughout the region (McGregor et al. 2008) (see Table 7).

Table 7: Importance of subsistence production in household wellbeing

	Samoa	Kiribati	Tonga	Solomon Islands	FSM	Palau	Tuvalu
Subsistence production as % of household income	26%	21%	17%	37%	23%	3%	55%
Sales of own produce as % of income	3%	11%	14%	6%			2%
Range of contribution of home production (subsistence and sales) to income	7-42%	19-50%	14-36%	7-71%	15-36%	n/a	30-65%
Subsistence agricultural production as a contribution to GDP	11%	48%	7%	n/a	22%	n/a	13%
Source: (McGregor et al. 2008)							

In Solomon Islands, for example, average value of production for home consumption is equivalent to about 37 per cent of the household income. Households also derive about 6 per cent of their income from selling surplus produce. On the other hand, in Palau, it is only 3 per cent. Pacific communities also largely rely on their domestic foods for much of their nutrition. McGregor et al (2008), note that for PNG, for example, 83 per cent of the food energy, and 76 per cent of protein consumed by people in 2006 was derived from locally grown foods. In Vanuatu a very detailed study of food production on Malo Island suggested that almost 80 per cent of villagers' food energy needs came from locally grown food. On the other end of the spectrum, Fiji has a much higher percentage of calorie (58 per cent) and protein (60 per cent) needs met from imported foods.

Such average statistics, though, mask the impacts of climate change on people's livelihoods. Two cyclones of intense magnitude in 1985 and 1986 in Vanuatu, caused considerable economic hardship among the affected rural communities. Many families on the island of Tangoa, South Santo, which predominantly depend on copra for their economic wellbeing had no income for about two years because their coconut trees failed to produce coconuts (Warrick 2007). Similarly on Guadacanal island in Solomon Islands, Weather-coast communities face food shortage following cyclones so often that they call these '*time blong hungry*' (Jackson et al. 2006). To meet the basic costs of everyday living, such as education fees, medical costs, and even to feed the family, such communities have to rely on their families, and *wontoks,* living in town or abroad for assistance (SPREP nd). However, with modernisation and weakening of traditional ties, families are finding that such social relationships and traditional safety nets cannot always be relied upon (Warrick 2007).

In Vanuatu, it has been reported that local communities have better adaptive capacity when they were less integrated into the market economy and were more self-sufficient. This though can be a double-edged sword. Market integration of local communities could also mean greater economic wellbeing of the people, at least for those who are actively involved in commercial activities or are in employment. This could also mean that they may have lower risks and greater adaptive capacity to cope with the effects of disasters.

Some positive effects of climate change on agriculture

Increased greenhouse gas emissions, global warming and associated climate change are also expected to have some positive impact on agriculture, although negative effects are likely to dominate and are likely to be of particular concern to the poor. Crop yields are generally expected to increase with increasing carbon dioxide concentration in atmosphere by almost a third with a doubling in carbon dioxide concentration (Hay et al. 2004). Different crops, however, will respond differently because crop yield is a product of many physiological processes, including carbon dioxide amounts (Hay et al. 2004). Many of the crops of particular interest to the Pacific, root crops (such as cassava, taro, yam, and sweet potato), vegetables (tomatoes, beans, cabbage, squash, and cucumber), fruits (mango, melon, bananas, papaya and citrus), and plantation crops (coffee, cocoa, and coconut) will have a better yield response than crops such as sugar cane (Hay et al. 2003). The effects will vary depending on the changes in solar radiation, cloud cover, and increases in temperatures.

On balance, though, climate change will have a much greater negative effect than a positive one and will have significant impact on food and nutrition security and people's basic livelihoods, particularly when a large proportion of them either live around or below the basic poverty line.

Fisheries

Food and income security in the Pacific are also closely tied to people's access to local fisheries resources particularly when for most PICTs their 200 mile EEZ is orders of magnitude larger than their land mass (Table 8). Oceanic and coastal fisheries resources are therefore important sources of food, income and national economic development (Table 9 and 10).

Table 8: Geophysical characteristics of Pacific Island Countries

Country	Area (sq km)	EEZ (sq km)	Ratio of Ocean to Sea Area	Population*	Population Density (persons/ (sq km)
American Samoa	197	390,000	1,980	57,496	292
Fiji	18,376	1,290,000	70	931,741	51
Guam	549	218,000	397	175,877	320
Kiribati	726	3,550,000	4,890	110,356	152
Marshall Islands	720	2,131,000	2,960	63,174	88
Federated States of Micronesia	702	2,978,000	4,242	107,665	153
Nauru	21	320,000	15,238	13,770	656
New Caledonia	19,103	1,740,000	91	224,824	12
Northern Mariana Islands	475	1,823,000	3,838	86,616	182
Palau	500	629,000	1,258	21,093	42
Papua New Guinea**	462,840	2,402,288	5	5,931,769	13
Samoa	2,944	127,950	43	217,083	74
Solomon Islands	29,785	1,340,000	45	581,318	20
Tonga	696	700,000	1,006	119,009	171
Tuvalu	26	900,000	24,167	12,177	468
Vanuatu	12,189	680,000	56	215,446	18
Cook Islands	180	3,550,000	4,890	18,000	100
French Polynesia	3,521	5,030,000	1,429	259,596	74
Niue	258	390,000	1,512	1,444	6
Wallis and Futuna	124	300,000	2,419	16,309	132
Tokelau	12	290,000	24,167	1,433	120

*All other demographic records are from census 2000

**. Papua New Guinea is not shown as its large land mass is atypical of other Pacific Islands.

Sources: SPC (1999) and GPA (1996).

Table 9: Annual volume of fisheries production (tonnes) in the late 1990s

	Subsistence Fishing	Coastal Commercial Fishing	Offshore Local Fishing	Offshore Foreign Fishing	Total
PNG	26,000	5,500	50,500	85,000	167,000
Kiribati	10,000	6,000	0	132,000	148,000
FSM	5,000	5,000	2,499	127,000	139,499
Solomon	13,000	3,200	73,328	948	90,476
Tuvalu	880	220	0	40,532	41,632
Nauru	110	315	50	41,000	41,475
Fiji	21,600	9,320	5,500	917	37,337
Marshall	2,800	444	0	33,217	36,461
Samoa	4,293	3,086	5,156	100	12,635
Tonga	2,863	4,173	800	45	7,881
Palau	1,250	865	2,500	124	4,739
Vanuatu	2,700	230	0	118	3,048
Cook Is	795	80	75	300	1250
Niue	194	12	0	2	208
Total	91,485	38,445	140,408	461,303	731,641
Source: (Gillet and Lightfoot 2001)					

Table 10: Fisheries Output (in late 1990s) ($US '000)

	Subsistence	Coastal Commercial	Offshore Local	Offshore DWFN	Total	% inshore
Cook Islands	1,164	10,320	397	407	12,288	93%
Federated State of Micronesia	10,000		2,485	144,000	156,485	6%
Fiji Islands	24,675	12,232	25,640	555	63,102	58%
Kiribati	7,890	6,310	-	132,259	146,459	10%
Marshall Islands	3,836	973	-	50,000	54,809	9%
Nauru	332	1,118	250	36,774	38,474	4%
Palau	2,500	2,595	12,500	270	17,865	29%
Papua New Guinea	20,227	21,394	44,344	75,074	161,039	26%
Samoa	7,143	6,583	9,840	99	23,665	58%
Solomon Islands	8,061	1,902	69,242	827	80,032	12%
Tonga	3,992	19,856	3,676	104	27,628	86%
Tuvalu	931	284	-	38,000	39,215	3%
Vanuatu	3,975	682	-	253	4,910	95%
Total	94,726	84,249	168,374	478,622	825,971	22%
Source: Gillet and Lightfoot (2001)						

Vulnerability of the community is closely linked to the sensitivity of the coastal and oceanic ecosystems and fisheries resources to climate change, with climate change expected to affect both the offshore tuna fisheries, a major source of foreign exchange, as well as coastal fisheries which are important for local food security.

Climate change and tuna fisheries

Oceanic tuna fisheries are by far the most important source of income and export revenue in the Pacific. It contributes about 11 per cent of the GDP of all PICTs (Gillet et al. 2001) and accounts for around 50 per cent of the total exports from the region. For employment too, tuna fisheries is very important, providing direct employment for 10,000 locals together with an indirect tuna-related employment estimated at between 11,000 and 21,000, accounting roughly for between five and eight percent of all wage employment in the region (Gillet et al. 2001). For PICTs that have local canneries (e.g. Fiji, PNG, American Samoa and Solomon Islands), tuna industries also help increase gender equity in the formal employment sector, contributing about five per cent of formally employed women in the Pacific.

Almost 1.4 million tonnes of tuna, valued at US$3 billion, are caught by distant water fishing nations and domestic fleet from the Pacific Islands EEZ (Gillett and Santen 2008). These fish know no national boundaries and the distribution of migratory tuna in the Pacific Ocean is dependent on the El Niño Southern Oscillation (ENSO) which is an interannual mode of variability in the ocean and atmosphere. ENSO has two dominant phases: El Niño and La Niña, with occasional years in which 'neutral' conditions are experienced. Model simulations suggest that climate change will result in climate conditions similar to present-day El Niño conditions with an increased interannual variability (Timmermann et al. 1999). This is likely to have significant impacts on the distribution of western and central Pacific tuna stocks and fisheries. It may also affect the productivity of PICTs' EEZs.

The IPCC has indicated that there are two main effects of climate change on tuna: a decline in total stock and a migration of the stock westwards both of which will lead to changes in the catch in different countries (IPCC 2007). Simulations of the effects of climate change on skipjack tuna habitat suggest a general extension of favourable habitat east of the dateline and to higher latitudes (Loukos et al. 2003). Recent work has also demonstrated the importance of the western Pacific warm pool for production of yellowfin tuna, such that an expanded warm pool may lead to increased production.

In El Niño years, the western Pacific warm pool, which defines the core habitat of two of the principal market species of tuna (skipjack and yellowfin), expands generally eastwards in tropical waters, while contracting slightly westwards in northern equatorial waters. In La Niña years the warm pool is largely constrained to the western tropical Pacific, while expanding slightly to the east in northern equatorial waters. Tunas are well adapted to climate variability and undertake large-scale movements through the western and central Pacific Ocean. These movements lead to high and low catches in the different fisheries operating with relative benefits/losses depending on where the fishery is located and its ability to re-locate as conditions change. Some PICTs will have a decline in tuna stocks while at the same time others, such as the Melanesian countries, could realise an increase in tuna stocks in their waters due to changes in the migratory patterns

The location of areas of high/low tuna catches shift during the different ENSO phases, and the exact location of tunas is difficult to predict. The DWFNs fleet should be able to adapt to changes in the spatial distribution and abundance in tuna stocks, as they usually hold access rights to multiple EEZs. On the other hand, domestic fisheries of PICTs would be constrained geographically to their EEZ, and thus they are less able to adapt to climate variability and future climate change.

The vulnerability of national economies to changes in the tuna fishery due to climate change will vary across the Pacific because of the differential importance of tuna fisheries in domestic economy. In some cases, even a one per cent change in tuna stock in countries highly dependent on the tuna revenue could have significant impact on governments' revenues and national wellbeing (Table 9).

Coastal ecosystems and food and nutrition security effects of climate change
Coastal ecosystems are also important sources of economic development, as well as food and nutrition security throughout the region. In Vanuatu for example, coastal fisheries accounted for about 95 per cent in fisheries GVP of US$3.9 million. Of this, subsistence catches accounted for 85 per cent of the value (Table 9). In Fiji, the GVP of fisheries was US$24 million, and of which subsistence fisheries accounted for 39 per cent.

In many countries, fish products form an important source of protein. In Solomon Islands, for example, 94 per cent of dietary animal protein is derived from fish, and over 70 per cent of the fish consumed by households comes from subsistence fishing (Table 11).

Table 11: Percentage dietary animal protein derived from fish, percentage of food fish caught by subsistence fishing, and current annual per capita fish consumption in the Pacific

	Animal Protein (%)		Subsistence Catch		Per capita fish consumption (kg)	
	Rural	Urban	Rural	Urban	Rural	Urban
Melanesia						
Fiji			52	7	25	15
New Caledonia			91	42	55	11
PNG			64	n/a	10	28
Solomon Islands	94	83	73	13	31	45
Vanuatu	60	43	60	17	21	19
Micronesia						
FSM	80	83	77	73	77	67
Kiribati	89	80	79	46	58	67
Nauru*	71	71	66	66	56	56
Palau	59	47	60	35	43	28
Polynesia						
Cook Islands	51	27	76	27	61	25
French Polynesia	71	57	78	60	90	52
Niue*			56	56	79	79
Samoa			47	21	98	46
Tonga*			37	37	20	20
Tuvalu	77	41	86	56	147	69
Wallis & Futuna*			86	74	74	74

*Values are national averages (data not available for urban and rural areas)
Source: SPC (2008)

Any changes in coastal fisheries due to climate change can have drastic impact on the household livelihoods and wellbeing and the communities' ability to meet their basic food and nutritional requirements.

Cost assessments

Coastal ecosystems are complex and dynamic systems; there are many diverse physical processes at work that influence coastal and marine ecosystems. Scientific understanding is limited even for developed countries and the economic costs of climate change are difficult to predict (Sheaves et al. 2007). For the Pacific, basic understanding of the marine environment is limited and science-based projections about the physical effects of climate change on coastal fish production and associated economic costs in the Pacific is almost non-existent. To get an indication of the economic costs of climate change on coastal fisheries, it may be useful to look at the nature of impacts climate change may have on different aspects of the marine ecosystem (Box 7).

Coral reef ecosystems

Coral reefs, and associated coastal ecosystems, are valued for the goods and services that support coastal fisheries, provide building materials, and provide natural beauty and aesthetic values that support and encourage tourism. Coral reefs are also valued for the many ecological services, such as coastal protection. With the projected increases in sea-surface temperatures, the thermal tolerances of reef-building corals are likely to be exceeded within the next few decades. Coral reef bleaching has also been associated with climate change. While empirical information in the Pacific is limited, Fiji reported serious coral bleaching in 2000 and 2002, with 40-80 per cent of coral mortality on many reefs. Some recovery, albeit slow, has been reported in places, such as the Beqa Barrier reef and the western Astralobe reefs, which reported slow recovery. Overall, only about 10 per cent of the coral reefs affected by bleaching in the southwest Pacific during 2000-2002 have recovered to their pre-bleaching levels (Lovell et al. 2004).

Box 7: Possible Pathways for Climate Change Impacts on the Coastal Ecosystems

- Increases in sea temperatures and associated changes will impact on species and species groups, and the flow-on effects on higher trophic levels;
- Increased temperature and changes to coastal circulation will affect nutrient supply and ecosystem dynamics;
- With increased storm surges and cyclones, increasing coastal erosion is also likely to have temporary and in some cases longer term impact on the productivity of mangroves, coral reefs and seagrass beds;
- Sea-level rise will increase inundation of coastal areas, affecting coastal habitats such as mangroves and other wetlands, and land-based activities;
- Productivity of coral reefs will also suffer from more frequent switches in El Nino and La Niña events;
- Increase in dissolved carbon dioxide and acidification of the seawater are believed to cause coral bleaching and coral mortality, affecting the trophic food chain relationship, and ultimately subsistence and commercial fisheries; and
- Wave and wind actions caused by extreme weather events, are expected to damage coral reefs.

Globally, coral bleaching in 1998 is known to have led to a loss of 16 per cent of the world's coral reefs, and economic impacts and recovery patterns though are not uniform. Cyclones also cause physical damage to reefs (Cyclone Heta in 2000, for example, caused damage to some 13 per cent of coral reefs in Samoa (World Bank 2006)).

More importantly, climate change will add to the existing stresses on the coral ecosystem due to human activities on land and the sea. Most of the countries have reported concerns about over-fishing, pollution and habitat destruction. Such effects are often localised and their cumulative effects can vary from low to very high within a country (Table 12). Climate change will exacerbate the effects of existing stresses of human activities and the effects will be highly localised, requiring localised targeted adaptation strategies to reduce risks.

Table 12: Perceived local threats and severity of those threats to some selected coral reefs of Fiji

Reef Area	Coastal Development	Pollution	Sedimentation	Overfishing	Destructive Fishing	Overall
Tavueni/ Somosomo	Non/low	Medium	Low	Low	Non	
Suva	Medium	High	High	High	Medium	Very High
Beqa	Medium	Non/Low	Low	High	Low	Medium
Coral Coast	Medium	Non-/Low	High	High	High	High
Mamanucas	Medium	Low	Medium	High	Low	Medium
Lautoka	Medium	High	High	High	Medium	Medium

Source: (Lovell et al. 2004: 341)

In Fiji and Solomon Islands, over 50 per cent of their coral reefs are considered to be under medium to high risk (Table 13). Climate change will exacerbate the effects of such stresses, affecting commercial and subsistence fisheries as well as tourism (see, e.g Webster and Hill 2007 and various chapters in Johnson and Marshall 2007).

Table 13: Variation in risk level of coral reefs in selected countries

	Reef Area (sq km) by degree of risk				Percentage under risk			Marine Protected Area	
	Total (km²)	Low	Medium	High	Low	Medium	High	No.	Area (km²)
Fiji*	10,000	3,360	4,800	1,900	34%	48%	19%	1	1
French Polynesia	6,000	4,900	1,100	0	82%	18%	0%	1	124
Marshall Islands*	6,000	4,900	1,100	0	82%	18%	0%	2	163
New Caledonia	6,000	5,800	200	0	97%	3%	0%		
PNG	12,000	6,000	4,500	1,500	50%	38%	12%	8	2149
Solomon Islands	6,000	3,000	2,500	500	50%	42%	8%	-	-
Source: Bryant et al. (1998)									

Mangroves
Recent analysis of the impact of sea-level rise in the Pacific indicates that the region could lose about 13 per cent of the 524,369 ha of mangroves by 2100 (Ellison et al – see table). Of these, 83 per cent will be lost from Melanesian countries with significant economic costs. Using economic values of mangroves reported for the Pacific (Lal 1990; Naylor 1998), the economic cost of the loss of 524,369 ha mangroves projected by 2100 due to climate change could be in the range of US$24 million-470 million a year, with the upper estimate including ecological services values (reported in Lal 1990).

Economic impact on Coastal fisheries
The collective impact on coastal fisheries due to climate change could be significant for many countries. A World Bank study of Fiji estimated an expected loss due to climate change in commercial fisheries around Viti Levu to be in the vicinity of US$0.05-0.8 million. The loss in subsistence fisheries is expected to be around US$0.1-2.0 million, whereas loss in coastal habitats is valued at about US$4.8-10.8 million. In the absence of detailed scientific information, these estimations are based on some broad assumptions (e.g. the functional relationship between climate change and changes in fish production) and available ecological information and local knowledge about reliance of inshore fisheries on coral reefs and mangroves and the expected impact of climate change on these ecosystems, and average information on the economic values of mangrove and coral reef dependent fishes.

Coastal zone and infrastructure
In most PICTs, the majority of populations reside on the coast, including many large urban settlements. On small Pacific atolls, entire populations are located in coastal areas. Throughout the Pacific key infrastructure such a hospitals, power stations, fuel tanks, farms, and schools are located in the coastal and island areas.

With changes in sea level and in the magnitude and frequency of storm events, coastal areas will be under increased risks of salt-water inundation, flooding and physical damage associated with coastal erosion. Climate change will also present several challenges for transportation in PICTs, including closure of roads, airports and bridges due to flooding and landslides, and damage to port facilities. The resulting disruption on infrastructure would also have implications for other sectors, with associated impacts on water and sanitation, food security and markets.

Coastal areas are already experiencing additional pressure associated with urbanisation and population growth. These pressures will accentuate the impact of other problems due to poverty and other forces such as pollution, poor waste disposal, limited access to water and sanitation, poor housing and limited access to utilities and public services such as schools and hospitals. Poor infrastructure and limited services means poor human capital, limited financial capital, etc, as discussed earlier, increase the vulnerability of coastal settlements the impacts of climate change.

With globalisation, there is also the added pressure of modernisation that is affecting vulnerability to disasters. In many rural parts of the Pacific, traditional housing styles and building techniques were found to be generally resistant to damage from cyclones. Communities also practiced risk reduction strategies, such as dismantling their houses when cyclones were imminent, and taking shelter elsewhere till the cyclones had passed. Traditional houses could easily be repaired at low costs (Warrick 2007). Recent trends in replacing traditional houses with 'block houses' have increased vulnerability as households damaged by cyclones require access to finance for repairs, and house reconstruction was usually slow after storms and flooding.

Economic costs and infrastructure
Local livelihood of people living along the coasts is also under threat from SLR. An assessment of the impact of sea-level rise on port facilitates in Suva, Fiji (Nunn et al. 1994a) indicated that wharves would be overtopped if sea level rose by about 50 cm and harbour experienced winds and waves associated with one-in-50-year cyclones. However, no cost estimates are provided. Economic estimates determined by the World Bank suggest that with expected changes in climate conditions, for example, by 2050, a one-in-50-year storm event and associated inundation could impact on 0.6-5.9 per cent of coastland, producing an estimated annualised economic costs in Fiji of about US$3-6 million a year (World Bank 2000).

In Vanuatu, a study of the replacement costs of different categories of buildings, and other infrastructures, such as airports, roads, harbours, in Port Vila, estimated an average replacement cost of AU$260 million. This estimate was derived using computer modelling of average cyclonic winds based on historic records back to 1950, calibrated against the effects of Cyclone Uma in 1987[6]. On the other hand, the worst-case cyclone and associated events could cause losses in Port Vila of about AU$640 million.

In summary, the implications of climate change for infrastructure and human settlements, particularly rapidly growing urban centres along the coast, are not well understood for the region, although available evidence suggests that the impacts will be significant and could easily undermine private sector-led economic development. Nonetheless, a risk-based approach to adaptation should be developed such that even in the face of inevitable uncertainty a 'no regrets' outcome position is taken within the context of national development.

Water
The effects of climate change on the water sector will affect many of the human development goals, including MDG 7 target 10 on access to clean water and sanitation. Freshwater in small islands is often classified in two main categories (Falkland 2002): 'conventional' water resources, which includes rainwater collected from artificial or natural sources, surface water and ground water; and 'non-conventional' sources which includes, seawater or brackish water desalination; or water importation by barge; treated waste water, and water substitutes (such as coconuts during droughts. Other 'non-conventional' water resources include the use of seawater or brackish water for selected non-potable requirements. Typical water uses include water supply to communities, tourism and hydroelectricity (as summarized in Table 14).

Table 14: Freshwater sources and main uses other than domestic

Country	Main Freshwater Source	Non-domestic use
Cook Islands	SW, GW, RW	T
Fiji Islands	SW, GW, RW, D (tourist resort only)	T, H, I, B
Kiribati	GW, RW, D (limited)	
Marshall Islands	RW (airport catchments and buildings), GW, D (emergency)	
Federated States of Micronesia	SW, GW, RW	
Nauru	GW, RW, D	
Papua New Guinea	SW, RW, D	M
Samoa	SW, GW, RW	T, H
Solomon Islands	SW, GW, RW	
Tonga	RW, GW, SW(limited)	
Tuvalu	RW (primary), GW (limited), D (emergency)	
Vanuatu	SW, GW, RW	

RW = rainwater, SW = surface water (rivers and streams), GW = ground water; D = desalination, T = tourism, H – hydroelectricity), B- export of bottled water, M – mining, I – irrigation
Source: Falkland (2002)

[6] Cyclone Uma, probably the largest single recorded disaster in Vanuatu to date caused over AUD$100 million damage in Port Vila alone.

Almost all the PICTs have issues related to reasonable access to water. According to the available information, the proportion of people that have access to safe drinking water ranges from 44 per cent in FSM, to close to 100 per cent in Cook Islands and Tonga (Table 15). Even where there may be universal access to water, water quality is not always assured, affecting basic health as well as water- and vector-borne diseases.

Table 15: Percentage of the population with access to safe drinking water

Country	UNDP 1999	ADB 2001	% rural population with access to improved water (UNESCAP/ADB/UNDP 2007
Cook Islands	95	99	88
Fiji Islands	77	77	51
Kiribati	76	76	53
Marshall Islands	82	82	96
FSM	44	44	-
Nauru	100	100	-
Papua New Guinea	24	41	32
Samoa	90	68	87
Solomon Islands	64	64	65
Tonga	92**	100*	100
Tuvalu	84	85	82
Vanuatu	87	77	52

United Nations Development Program (UNDP 1999; ADB 2001; UNEP and SPREP 2005)
UNDP/ADB/UNDP 2007: Millennium Development Goals: Progress in Asia and the Pacific 2007.
** (UNDP 2005); *** (SPC and UNDP 2004)

Climate change impact

Any change to the water cycle is expected to cause increased problems of access to safe water. The direct impact of climate change effects on water will be felt mainly through two pathways: increased incidence of drought and excessive water. The actual availability of usable water will be influenced by multiple factors including:

- climate variability in the short term (such as cyclones), at the interannual scale (ENSO), and in the long term (through global climate change);
- natural and human-managed hydrology; and
- the geographic relationships between rainfall, supply infrastructure, and population.

Although water shortages are typically most severe on atolls and small islands, large islands are also susceptible to climatic variations, mainly induced by the ENSO.

The frequency and severity of ENSO events have been increasing in the region over the last two decades (SOPAC 2002). The ENSO associated droughts in the period 1998-2000 for example, resulted in some of the worst water shortages on record across much of the region, including in the RMI, Kiribati, Nauru, PNG, Fiji, Tonga and Samoa. A national emergency was declared in FSM in 1998 when 40 atolls ran out of water, while the RMI imposed severe water rationing, declaring the country a natural disaster area and brought in desalination plants (Burns quoted in SPC and UN 2004). Kiribati declared a state of emergency in 2000 after a prolonged drought associated with the La Niña seriously affected some outer islands.

Even where Pacific islands have reasonable access to safe drinking water, many rural areas face problems particularly during extended drought periods, requiring urgent attention from the state. In Fiji and Tonga, water is sometimes transported by boats or barges to outer islands without surface or groundwater during extended periods of drought. In many countries, such as Solomon Islands, the costs of such action are so high that it is not an option.

Small atoll islands reliant on rainwater harvesting combined with groundwater extraction are particularly vulnerable. Most climate models predict an increase in the frequency of ENSO episodes and in the intensity of cyclones. Large waves associated with tropical storms can cause contamination of groundwater supplies in atolls and small islands. Some islands such as Funafuti in Tuvalu have no substantial freshwater lenses due to groundwater pollution and saltwater intrusion and are consequently totally dependent on rainwater harvesting with desalination as an emergency option. In Solomon Islands, the outer coral atoll islands of Ontong Java in the Torres Island Groups, drought is a real concern with over 70 per cent of the residents believing that drought has caused major impacts on their livelihood (CLIP Research Project 2007).

Any changes in the water cycle will thus have devastating effects on human welfare. Indirectly, too, climate change effects can cause major disruptions in lifestyles, particularly where water is used for hydroelectricity, such as in Fiji and Samoa. For example, in Fiji, the Fiji Electricity Authority has recently been struggling to ensure constant supply of electricity to its consumers because of a drop in the water level in the Monasavu dam that feeds hydroelectricity generators.

Water and Health

Among other indirect effects of increased precipitation, increased incidence of water- and vector-borne diseases could affect countries' ability to meet their MDG targets (Table 16). Even where the countries show favourable achievement against their MDG, it masks the challenges countries face because of the highly dynamic nature of the relationship between water, sanitation and human health.

Table 16: State of Pacific Island countries performance in regards to key MDGs

	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 7
	Poverty and hunger reduction	Universal primary education	Gender equality in education	Reduced child mortality	Reduced maternal mortality	Access to water and sanitation
Indicator	% Population under nourished	Children reaching Grade 5 as a percentage of grade 1 pupils	Secondary school enrollment ratio	Children under 5 deaths per 1,000 live births	Deaths per 1000,000 births	% rural population with access to improved water
Melanesia						
Fiji	4	**95.8**	**1.07**	**18**	75	51
PNG	13	58.2	0.79	74	300	32
Solomon Islands	20	**78.0**	0.83	**29**	**130**	**65**
Vanuatu	12	70.6	0.86	38	**32**	52
Polynesia						
Cook Islands	-	-	**1.02**	**20**	-	**88**
Niue	-	-	**0.95**	-	-	**100**
Samoa	**4**	**95.9**	**1.12**	**29**	**15**	87
Tonga	-	**94.6**	**38**	-	**100**	
Tuvalu	-	62.6	**0.93**	38	-	**82**
Micronesia						
FSM	-	-	-	-	-	-
Kiribati	**6**	**81.4**	**1.13**	65	-	53
Marshal Islands	-	-	**1.05**	58	-	**96**
Nauru	-	**25.4**	**1.07**	30	-	-
Palau	-	-	**1.08**	**11**	-	**94**

\- **no data available**

Areas of Concern

Source: UNESCAP/ADB/UNDP: Millennium Development Goals: progress in Asia and the Pacific 2007

Water-borne health issues in the Pacific arise due to poor management of human and animal waste, seriously affecting the water quality of groundwater, surface water and the marine environment in low-lying atoll islands, raised limestone islands as well as coastal areas of high volcanic islands. Pollution of ground and surface water is common in places like Tuvalu, Cook Islands, Tonga, Kiribati and parts of Fiji. In places like Tuvalu, pollution of the groundwater combined with saline water intrusion has made the use of freshwater lens for human consumption impossible.

Limited water availability is also expected to affect basic human hygiene, although the relationship is mixed. Singh et al (2004) found that low-lying atolls such as Tokelau, Tuvalu, and Kiribati tend to have the highest average temperatures and among the lowest potential water availability and the highest rates of diarrhoea. They also found that there is a strong relationship between climate variability and rates of diarrhoea. A connection between temperature, rainfall and diarrhoea was found for Fiji, particularly in relation to infant diarrhoea. On the other hand, in Vanuatu, increased incidence of diarrhoea and skin diseases was associated with high rainfall and/or storm water surges (Box 8).

Box 8: Relationship between increased rainfall, vector-borne and water-borne diseases

Past experiences in the Tegua community, Vanuatu have shown that following a flooding event, an increase in skin diseases and infections as well as malaria infections follow. Floodwater provides breeding areas for mosquitoes, and a medium through which water-borne diseases are transmitted. Given that the water table is close to the surface, pools of water are visible for days making it a good breeding ground for mosquitoes. Furthermore extensive salt marshes located behind the village contribute significantly to flooding in the event of heavy rainfall.

What is compounding the effects of storm surges and increased rainfall in the village is the outflow of open pit-toilet wastes into flooded areas. Given the limited availability of freshwater on the island, people do not have may options for washing and bathing purposes. Moreover, with children playing in flooded areas and muddy waters, together with limited availability of fresh water, an increase in the spread of water-borne diseases, such as skin rashes and boils, fungal diseases and conjunctivitis is likely.

The impacts get further magnified because the health aid post on the island is overstretched in terms of medicine and other supporting equipment needed. People will then be ferried across to the health station situated on another island called Loh or, for serious cases, airlifted to Santo.

Source: Nakalevu and Phillips (2007)

In Samoa, Saoluafata and Lano communities in Savai'i are more prone to health hazards with favourable conditions for vector- and water-borne diseases (SPREP nd). Water-related human health effects are likely to be magnified due to the effects of salt water intrusion due to sea-level rise. It is important, though, to note that scientific evidence about salt-water intrusion is contradictory (see Box 9).

The patterns of many vector-borne and other infectious diseases are known to vary seasonally and inter-annually in response to changes in weather (Campbell-Lendrum and Woodruff 2007).

The IPCC concluded that climate change is likely to expand the geographical distribution of several vector-borne diseases, including malaria and dengue to higher altitudes (high confidence) and higher latitudes with limited public health defences (medium/low confidence), and to extend the transmission seasons in some locations (medium/high confidence). For some vector-borne diseases in some locations, climate change may decrease transmission by reductions in rainfall or temperatures too high for transmission (medium/low confidence). Such projections are a serious issue for the Pacific, particularly for countries where malaria is widespread, such as Vanuatu and the Solomon Islands. The Solomon Islands reported 163 per 1000 cases in 2001, although in the past this has been as high as 437/1000 people (WHO 2002). Increases in vector-borne diseases, particularly malaria, dengue and filariasis, are also correlated with high rainfall.

Box 9: Contradictory evidence about the effects of salt-water intrusion

Recent studies have shown that 40-50 cm SLR would have virtually no impact on the groundwater supplies – and may even increase the volume because the top of a freshwater lens would rise while the base remained unchanged. This assumes the width of islands is not reduced by inundation or erosion in the future. If this occurs then the lens will shrink between larger islands and 'virtually disappear' under small islands (Roy and Connell 1991). Recent study on the impact of SLR on Bonriki lens in Kiribati concluded that a reduction in the width of the island would reduce the thickness of the lens by 20 per cent (East West Center 2001). Concomitant reduction in island width and SLR could seriously reduce volume of freshwater lens. A 50cm SLR and 25 per cent reduction n rainfall could reduce the Bonriki lens by 65 per cent – most of the impact was due to that attributable to the reduction in precipitation. Increase in SLR – water tables to rise close to the surface and groundwater becoming no longer potable.

Source: Falkland (1991a); EWC (2001).

Economic costs of health effects
Information about economic costs of climate change-induced human health effects associated with water- and insect-borne diseases across the Pacific are limited. While it is difficult to draw absolute correlation at the aggregate national level, because of the confounding influences noted above, increased incidence of water- and vector-borne diseases in Vanuatu appear to be related to the years when the country suffered a series of cyclone events. Thus, for example, in the period 2002-2003, Vanuatu saw five cyclonic events. During the same period the number of malarial incidence increased by almost 50 per cent as compared with the period 2001-2002.

Similarly, water-borne disease incidence, such as of diarrhoea, increased by almost 100 per cent over the same period. Assuming each known water-and-vector-borne disease incidence (Table 17) was treated with the standard medicines prescribed in Vanuatu, the average cost of medicine associated with climate-related diseases is around Vatu 6-14 million or about AU$542,000-AU$600,000 per year. It is strongly emphasised that this is only an indicative cost of climate-related diseases, as a much more detailed 'with and without' economic analysis is required that includes not only the economic cost of medicine but also other direct costs, such as the cost of foregone earnings, transportation costs used in Tuvalu for example (Lal et al 2005). There are also intangible costs which also need to be taken into consideration. The economic cost of health effects for climate change must also estimate the incremental cost associated with climate change per se. However, this too is fraught with difficulties in predicting the impacts because the relationship between climate change and diseases is context-specific, as it depends on not only the geophysical characteristics of the location, but also the current health status of people and the availability of health services in the region, as discussed earlier (Box 8).

Table 17: Incidences of water-borne and insect-borne diseases and cyclone and disaster events in Vanuatu, 2001-2006.

	2001	2002	2003	2004	2005	2006
Number of cyclones	2	1	4	1	1	
Malaria	20,023	34,163	42,332	40,983	32,435	25,226
Complicated malaria	1,471	1,054	1,082	920	842	885
Total Malaria	21,494	35,217	43,414	41,903	33,277	26,111
Dengue	20	15	122	21	2	7
Water Borne	807	1,721	1,679	2,780	2,057	1,713
Poor hygiene & water contact	29,081	40,509	41,403	64,218	61,483	48,085
Fish poisoning	580	683	811	854	898	786
Subtotal Costs (Low)	24,395,440	36,521,790	40,499,570	51,923,370	46,469,240	36,511,530
Subtotal Costs (High)	30,544,270	44,037,445	48,252,925	62,965,800	57,051,160	45,059,250

Source: based on Data provided by the Department of Health, pers comm, October 2008, and medicine costs provided by Port Vila Pharmacy, pers comm. October 2008

In Tuvalu, a detailed 'with and without' analysis of water-related costs associated with the effects of flooding together with poor human waste management gave an estimate of about AU$500,000 a year for a population of about 10,000 people (Lal et al 2005). These costs included not only water-borne human health costs, but also opportunity costs associated with having to access water for human consumption from other sources, such as desalination and imported bottled water. It also reflected the atoll conditions, the level of water table, quality of septic tanks, and the regular flooding conditions of the island.

Tourism

Climate is an important aspect of tourism experience, with good weather, sandy beaches and safe coastal settings being some of the major attractions. Climate influences the length and quality of tourists' experiences. Climate also affects a wide range of environmental resources that are critical for tourism attractions, such as the diversity of habitat and species of animals and plants; water levels and quality. Climate also affects a number of environmental conditions, such as water-borne diseases, algal bloom, and jellyfish that can deter tourists. In the region, diverse, colourful and healthy corals supporting a large diversity and abundance of fish species and the presence of megafauna, such as sharks, manta rays and turtles, are some of the attractions for the tourists.

Changes in any of these aspects of the environment may deter potential tourists from coming over to the Pacific. Most PICTs have reported coral bleaching associated with warmer coastal seas, with potentially drastic impacts on the tourism sector, an economic sector that many PICTs depend on. While local information is not available, the IPCC WG2 quoted global surveys which indicate that 80 per cent of tourists would not wish to return to bleached coral areas (IPCC, 2007).

Climate can also pose a severe risk in relation to extreme events such as cyclones and floods. Increased climate variability in weather conditions at a given location and time may prevent tourists from engaging in their planned activities. These put both tourists and tourism-oriented businesses at risk, including damage to tourism infrastructure and increased financial costs combined with lower incomes. For many of the PICTs such impacts can put back their ability to meet their basic development goals.

Tourist numbers in a country are dependent on a number of local, regional and international factors. However, even if there were to be a decrease in tourist numbers of one per cent due to the direct effects of climate change, impacts on national economies could potentially be very significant, particularly when tourism is seen as a major source of economic growth in most countries. In Vanuatu, for example, if the number of tourists were to decrease by one per cent, the expected foregone earnings will be about AU$25 million in direct tourist expenditure annually, or close to about 12 per cent of national GDP.

Forestry

Forests and trees have always been an integral part of the lives of Pacific island communities, and have played an important role in their general wellbeing. They have provided employment, income-generation opportunities and export earnings, as well as timber, posts, thatch, food, fuel, medicines, traditional and cultural materials, soil and water protection, and shelter from the sun, rain and wind. In many PICTs, especially on the smaller islands and atolls, agro-forestry and tree crops provide most of the food, medicines, construction materials, firewood, tools and a myriad of other products and services that cannot be replaced with imported substitutes.

Climate change is expected to exacerbate the effects of unsustainable forest uses in the Pacific. Forest loss and degradation are steadily increasing. The loss of forest areas through agriculture conversion, forest degradation arising from unsustainable logging, forest clearance for development and plantation establishment, are all contributing to the sensitivity of the local communities to the effects of climate change. The downstream effect of deforestation and soil erosion cause stress on coastal coral reefs and fisheries resource they support.

Concluding remarks

Climate change and climate variability will have significant impact on key sectors that support basic livelihoods in the Pacific, as well as on governments' ability to provide key services.

The sectoral impacts of climate change would directly and indirectly affect the key livelihood assets that support human livelihood at the individual, household or group levels. Carney (1998) defined these in terms of:

natural capital (i.e. quality and quantity of resource stock);
human capital (i.e. skills, knowledge, ability to work and human health help pursue livelihood activities);
socio-political capital (i.e. social relationships, social security, enabling environment of laws and custom);
financial capital (i.e. income level, savings, access to credit); and
physical capital (i.e. basic infrastructure, water, buildings energy etc).

Taken together, these livelihood assets would determine the ability of the households, communities and nations to adapt to climate change and other shocks.

Security implications

Climate change manifested in rising sea levels and more intense droughts and storms could stimulate large-scale movements of people within, and across, international borders. In the longer term, rising seas could also have sovereignty implications for some Pacific Island countries. Individually or collectively, such developments could destabilise countries internally, aggravate tensions between states, and endanger human security.

Secretary General Ban Ki-moon at the United Nations Security Council's first debate examining the relationships between climate change and security in April 2007 noted that projected climate changes would not only have serious environmental, social and economic implications, but also have implications for peace and security. He raised several scenarios that included limited or threatened access to energy increasing the risk of conflict, a scarcity of food and water transforming peaceful competition into violence and floods and droughts sparking massive human migrations, polarising societies and weakening the ability of countries to resolve conflicts peacefully (UN Security Council 2007).

At the UN Security Council meeting PNG's representative spoke on behalf of the Pacific Islands Forum indicating that the impact of climate change on small islands was no less threatening than the dangers guns and bombs posed to large nations, because PICTs are likely to face massive dislocation of people, similar to population flows sparked by conflict. The impact on identity and social cohesion was likely to cause as much resentment, hatred and alienation as any refugee crisis (UN Security Council 2007).

The linkages between climate change and security are still not well understood both conceptually and empirically particularly as they affect the Pacific. While the science is now unequivocal and points to very serious climatic changes that will have implications on natural resources leading to concerns over land, food and water scarcity, it is not clear what the human response to these changes will be nor what the relationship will be to peace and security.

The potential for some Pacific island countries from becoming uninhabitable due to climate change is a very real one. Sea-level rises may have dire consequences for low-lying atoll countries in the Pacific such as Kiribati, the RMI, Tokelau and Tuvalu. Periodic storm surges could well inundate up to 80 per cent of the land area of North Tarawa and 54 per cent of South Tarawa by 2050 with the economic costs expected to range between 10 and 30 per cent of GDP in any given year. By 2080, the flood risk for people living on small islands will be on average 200 times larger than if there had been no global warming and the risk could be even higher if the melting of polar ice continues at present rates. If temperature and sea-level rises are at the high end of those forecast, then the sea will either eventually submerge the coral atolls or ground water will become so contaminated by salt-water intrusion that agricultural activities will cease.

Ultimately, human habitation may not be possible even with moderate climate change. Potential evacuation of islands raises grave concerns over sovereign rights as well as the possibility of entire cultures being lost

(Barnett 2007) Larger more mountainous and populous islands such as Fiji will also be seriously affected. Some commentators contend that in a worst case scenario of sea-level rise, much of Fiji's productive land and urban areas would be flooded. This would exacerbate tensions between indigenous Fijians and Indo-Fijians who would find it extremely difficult to access new land. In time to come climate change could become a contributory factor towards social conflict and national security.

Given the IPCC predictions it is clear that without strong measures to reduce global greenhouse gas emissions, comprehensive adaptation in many PICTs will be very difficult.

Recommendation 2: *Urgently develop/strengthen specific geo-referenced baseline information related to key hazards, including socio-economic information, livelihood assets and their sensitivities to climate change.*

V. Adaptation Strategies

For the PICTs climate change is not a question of 'if' or 'when'. Climate change impacts are already being experienced throughout the Pacific. The critical issue is 'what?' individually and collectively can be done to minimise vulnerabilities of communities, economies and environment to the effects of climate change.

Climate change is a development issue, affecting all walks of life. Adaptation strategies, therefore, should reflect its multi-dimensional effects on livelihood assets of the people and the communities. As discussed above, the effects of climate change and climate variability have direct relevance to poverty, risk reduction and risk management as well as resource and environmental management. There is a direct correlation between poverty status and vulnerability to disasters, including climate change. Poverty increases vulnerability to disaster, while disaster also affects people's economic wellbeing, human health and other basic livelihood conditions. Poor people usually have substandard quality and, often, dangerous location of housing (e.g. on flood plains, riverbanks or steep slopes), and lower levels of access to basic services, which add to their sensitivity to hazards. Limited access to financial resources, further constrain their ability to diversify livelihoods and quickly recover post disaster. The poor can also exacerbate their own risks whereby limited livelihood opportunities force over-exploitation of the local environment. Meanwhile, the covariate nature of natural hazards implies that there is limited scope for formal and informal community-based support systems in the aftermath of a natural disaster.

There are thus three core categories of strategies that are relevant for improving adaptation to climate change:

- poverty focused development strategies;
- disaster risk reduction and disaster management; and
- sustainable resource and environmental management.

Efforts that lead to an improvement in the economic wellbeing of people, and the diversity of food and nutrition and income sources, will reduce their sensitivity to external shocks, reduce their vulnerability and also increase their ability to respond to disaster events. Improvements in basic human health conditions also reduce their sensitivity and improvements in human skills and capacity, increase their productivity and reduce vulnerability. Similarly, strengthened resource and environmental management can help to maintain ecological integrity and help reduce the scale and extent of impact of climate change.

Mindful of the encompassing nature of climate change, there is an urgent need to look at the wide range of sectors. Efforts to reduce disaster risk, improve the preparedness of households and communities to disasters, as well as improving early warning and communications strategies can all help increase adaptation to climate change. Tandem improvements on water and sanitation management, integrated catchment management; ecosystem-based management; or integrated coastal zone management, and an early warning system and communication, are necessary if climate change and disaster risk reduction are to be tackled effectively.

Practice in the Pacific

PICTs have already undertaken a range of adaptation measures. However, existing adaptation efforts will not be sufficient to cope with increased vulnerability to future climate change. PICTs will need to build on existing and past efforts and take strategic and innovative national action to identify and implement effective adaptation measures to address vulnerability and improve resilience.

Most vulnerability and adaptation assessments at the national levels have been carried out in the context of the preparation of initial national communications. These followed a model prepared by the Waikato University and the University of the South Pacific. Using simple simulations, the model allowed participants to make predictions on climate change impacts on vulnerable areas. Vulnerability assessments highlighted the following key sectors which have been affected by climate change and sea-level rise: coastal zone and coral reefs; agriculture and food security; marine resources; water resources; and biodiversity. Many of the proposed adaptation activities have a strong community based component, as the majority of the activities fall within the following sectors: coastal zone management, water resources management, food security and human health – all of which are directly linked to the communities, their wellbeing, livelihoods and prospects for sustainable development.

A number of lessons were learned from the various projects and programmes, including an Asian Development Bank project entitled Climate Adaptation in the Pacific Islands (CLIMAP), Assessment of Impacts of and Adaptation to Climate Change in Multiple Regions or Sectors (AIACC). Key observations from the projects include (Leary et al. 2007):

- past studies of adaptation options for PICTs have largely focused on adjustments to sea-level rise and storm surges associated with tropical cyclones;
- early emphasis on protecting land through 'hard' shore-protection measures rather than on other measures such as accommodating sea-level rise or retreating from it, although the latter has become increasingly important on continental coasts;
- vulnerability studies conducted for selected small islands show that the costs of overall infrastructure and settlement protection is a significant proportion of GDP, and well beyond the financial means of most small island states; and
- recent studies since the IPCC TAR have identified major areas of adaptation, including water resources and watershed management, reef conservation, agricultural and forest management, conservation of biodiversity, energy security, increased share of renewable energy in the energy supply, and optimised energy consumption.

The emphasis has thus become more broad-based and looks at climate change impacts from a more comprehensive perspective. The Pacific leaders have agreed that climate change is a development issue and adaptation to climate change will require a multi-pronged approach. However, the real challenge is in the execution of these commitments, particularly when the existing organisational arrangements, policies and plans, as well as external assistance encourage compartmentalisation and work in isolation. This is evident in the way climate change and disaster issues are addressed.

Regional Frameworks and National Plans of Action

The Forum Leaders have signed on to many key guiding principles and made commitments captured in various regional policies, plans of actions related to specific themes, including the two regional plans that directly deal with risk management related subjects relevant to climate change adaptations – Pacific Islands Framework for Action on Climate Change and the Disaster Risk Reduction and Disaster Management Framework for Action, endorsed in 2005. PIFACC deals with climate-related hazards and its actions are broadly categorised under the following key subheading 'principles':

- Implementing adaptation measures;
- Governance and decision-making;
- Improving our understanding of climate change;
- Education, training and awareness;
- Contributing to global greenhouse gas reduction; and
- Partnerships and cooperation.

DRR&DM Framework for Action deals with all hazards, including climate-related disasters. Its strategies are categorised under a similar set of key principles:

- Governance – organisation, institutional, policy and decision-making frameworks;
- Knowledge, information, public awareness and education;
- Analysis and evaluation of hazards, vulnerabilities and elements of risks;
- Planning for effective preparedness, response and recovery;
- Effective, integrated and people oriented early warning system; and
- Reduction of underlying risk factors.

The Pacific Leaders in 2005 called for the operationalisation of the PIFACC at the country level. To give effect to these strategies at the national level, specific national level actions need to be operationalised at all levels.

In-country governance

Pacific Island countries have implemented many discrete activities directly targeting climate change through usually the department that deals with environment. However, disaster risk management related activities have been promoted and or implemented through the national disaster management office, or its equivalent. External assistance, too, has been provided through these respective thematic areas, some with the assistance of the regional organisations mandated to address these issues under the Pacific: SOPAC for disaster risk management; and SPREP for climate change. Under both frameworks, efforts to mainstream the issue into national development planning have been highlighted as a priority. In some countries, these two are being implemented independently of one another, usually with the assistance of external agencies which also have difficulty in integrating the strategies and then coordinating their assistance (see Box 10).

With limited capacity, PICTS, too, are struggling integrate these two external assistances, often targeted at the two different parts of the government.

Box 10: Organisational arrangements in Solomon Islands

Disaster risk management issues are coordinated from the National Disaster Management Office. Climate change related initiatives are coordinated through the Climate Change Unit, now under the Department of Meteorology. External assistances from regional organisations are, too, divided along similar lines: SOPAC deals mainly with the NDMO; while SPREP often work with now the Climate Change Unit (previously it was the Department of Environment). NGOs too have their respective focal areas in the respective government agencies, depending on the subject matter being addressed.

Although the country has a National Coordinating Committee for Climate Change (NACCC), which helps coordinate, particularly external projects, on climate change, on-the-ground, disaster risk reduction and adaptation efforts are undertaken through the NDMO, without much explicit coordination.

There is an urgent need to integrate the two streams of assistance to countries and the development of a single-risk minimisation and risk management plan of action that deal with disasters, whether they have their origins in natural climatic events or those brought on by human-induced climate change.

Recommendation 3: *Develop an integrated Disaster Risk Reduction and Disaster Management Plan of Action, including for climate change related hazards.*

Sector level governance

No sector will be immune from the effects of climate change, either due to direct impacts or indirect flow-on effects. As discussed earlier, the impacts will be manifested through different pathways depending on which aspect of climate change and climate variability is triggered – temperature, precipitation and sea-level rise. The impacts are also dependent on the sectoral sensitivity, as well as the sensitivity of the local communities, economy and infrastructure.

Due to existing uncertainties in aspects of climate change science and communities most at risk, adaptation strategies must initially focus on sound ‘no regrets' approaches which may initially seek to build resilience to existing known climatic/oceanographic variability and extremes. These may include specific priority climate change-related issues under one or more of the livelihood assets as well as disaster risk preparedness and responses, including:

- Basic livelihood issues – food and nutrition security;
- Basic human well being – access to safe water and adequate sanitation, control of water- and vector-borne diseases, human health services;
- Ecosystem management and restoration activities;
- Disaster preparedness and response – early warning systems, including appropriate

disaster response messages and information; and
- Improved shelter and other infrastructure – appropriate housing, and coastal planning and zoning

It is critical that such adaptation strategies are community-focused and target risk reduction as well as resilience building. Adaptation approaches must seek win-win options whereby actions today help meet immediate needs for reducing risks but also create the basis for reducing future vulnerabilities and the capacity for more effective adaptation as impacts of climate change become more predominant (IUCN et al. 2003).

In PICTs, there is a need for tandem national level efforts as well. At the national level sector plans and programmes must incorporate climate change adaptation strategies that are practical and community focused. Mainstreaming of climate change, and disaster risk management, into their national planning and budgetary processes as well as sectoral level decision-making processes is seen as one such effort to place member countries in the driver's seat. Its benefits include the adoption of systematic and programmatic approach for guide countries' own efforts, as well as seeking coordinated and harmonised development partners assistance to complement their own initiatives. Climate change adaptation must target specific sensitivity areas as well as coping mechanisms to climate change effects, and translate these into actions that people can adopt to reduce their risks, but also increase their capacity to respond and cope with climate change effects.

International experiences suggest that there are a number of barriers, and thus opportunities, for mainstreaming climate change adaptation, including institutions, information, stakeholder inclusion, incentives, and finances (Institute of Development Studies 2006).

For the Pacific, efforts to improve adaptation in high-risk countries should include information based decision-making processes and mechanisms at appropriate levels to ensure that:
- appropriate policy frameworks exist to mainstream disaster risk reduction as a central element in development planning;
- strong institutional, legislative and regulatory arrangements and capacities are in place for disaster risk management;
- all relevant stakeholders, including poor, vulnerable groups, participate in disaster risk management policy and decision-making about specific adaptation strategies;
- all relevant stakeholders identify and prioritise structural and non-structural measures for adaptation;
- disaster risk reductions concerns are included all aspects of project cycle; and
- financial means and the institutional changes necessary to implement successful processes adaptations are clearly identified.

Pro-poor pro-vulnerable development strategies
Pro-poor development strategies have been promoted by the World Bank and the Asian Development Bank. PICTS, too, have incorporated these concepts in their national sustainable development plans and strategies, or their equivalent. Their development goals and targets, including MDGs and targets, also recognise poverty reduction as a major goal.

The strong two-way relationship between poverty and the impacts of climate and/or other natural disasters suggests countries must particularly focus on communities with poor economic and other human development conditions, as well as those that are highly sensitive to climate change and climate variability.

Recommendation 4: *Target communities and areas with poor economic and other human development conditions, as well as those highly vulnerable to climate change effects.*

Risk considerations must also become one of the criteria for selection of projects, for their design, project implementation and monitoring and evaluation. In the sectoral planning level, as well as project identification, design and implementation, disaster risk reduction concerns must be incorporated, using best available information and analytical methods and tools (Table 18).

Table 18: Mainstreaming disaster risk reduction into development projects in hazard prone countries

	Key strategies	Specific Activities
National development planning	• Poverty reduction strategies • NSDS, NSDP, or equivalent	• Situation analysis that incorporating the poverty-disaster link
Country Programming	• Sector planning incorporating DR analysis • Stakeholder analysis covering DRR policies • Previous DRR lessons learnt	• Hazard analysis & information • Government DRR policies, strategies & related initiatives
Project identification, design and appraisal	• Hazard information • Integration of DRR concerns within the overall project cycle • Logical framework / results based management analysis incorporating DRR concerns • Environmental analysis incorporating DRR concerns • DRR related legislations & implementation capacity (e.g. building standards & land-use zoning)	• Economic analysis incorporating DRR concerns • Social analysis incorporating DRR concerns • Choice of projects, project designs such as construction designs & sites selection, incorporating DRR principles • Lessons learnt from previous DRR initiatives
Implementation	• Monitoring of disaster risk • Review & possible adjustment of project activities & goals in the event of disaster	• Building code enforcement & monitoring of construction standards • Continuing stakeholder consultations on DRR
Monitoring and evaluation	• Analysis of impact of any disaster event on both project performance and operating environment • Analysis of long-term project sustainability in the face of disaster risk	• Stakeholder analysis on DRR aspects of the project • Analysis of benefits & achievements of DRR components • Impact of the project on vulnerability to natural hazards

***Recommendation 5:** Strengthen existing governance arrangements by, in the first instance, establishing organisational arrangements aimed at improving coordination of decision-making processes for policy formulation, planning and budgeting, programme design and implementation, and monitoring and reporting on climate change adaptation and disaster risk management.*

Tools for identifying adaptation strategies

Several different tools are reported in the disaster risk reduction and disaster management literature, including comprehensive hazard risk assessment and management, root case analysis, and problem and solution tree analysis. IUCN et al (2003) have proposed a three-staged process, each with several steps, which could form the basis for developing adaptation strategy that brings vulnerability–livelihood interactions to the forefront. Specific tools for mainstreaming disaster risk reduction, including climate change adaptation have been developed by the PROVENTION Consortium (see for example, Benson and Twigg 2007; and other references on the PROVENTION website, http://www.proventionconsortium.org/themes). In the Pacific, SOPAC has produced the CHARM, *Comprehensive Hazard Assessment and Risk Management*, as a toolkit for use as a 'management tool and/or processes within the context of integrated national development planning process'. Widely adopted methodology for assessing socio-economic effects of disasters is summarised in the handbook produced by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC 2003). In relation to climate change adaptation, methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change is summarised by the UNFCCC Secretariat (UNFCCC 2005). This is a most comprehensive publication that summarises three broad categories of frameworks, methods, and tools and:

1. reviews some of the complete frameworks (both what are previously referred to as first-generation approaches and second-generation approaches), those methods that prescribe an entire process for the assessment of vulnerability and adaptation and in some instances assemble toolkits to support this process;
2. provides a structure for cataloguing tools that assist in addressing key cross-cutting themes or whose application spans multiple steps of the assessment process, as well as discrete tools that are applicable to multiple sectors, including those that may constitute partial analysis (e.g. stakeholder analysis; socioeconomic scenario building, decision making); and
3. describes discrete tools specific to particular sectors.

The compendium provides users with key information about available frameworks and tools, special features of each framework or tool, and information about how to obtain documentation, training, or publications supporting each tool. It has been designed to be used as a reference document to identify available frameworks and tools for assessing vulnerability and adaptation strategies.

For small island states, Tomkins et al (2005) provide a climate change adaptation guidebook, which takes a step-by-step approach in understanding climate change risks, assessing vulnerability, and developing and implementing adaptation strategies, including integrating climate change into planning processes. Community level vulnerability assessment tool kits for the Pacific, for example, are reported by WWF (2008) and SPREP (nd).

Knowledge, Communication and Awareness

Adaptation responses in all sectors must be guided by sound baseline information: climatic, social, economical, and environmental. In order to build and maintain optimum environmental resilience to climate change stress, improved understanding and monitoring of climatic, oceanographic, coastal and hydrological systems, human resource use and settlement patterns must be improved. For example, improved mitigation and adaptation to cyclone induced flooding requires a better understanding of the hydrological behaviour of island fluvial systems during tropical cyclones than currently exists (Terry et al 2008).

Robust time-series data is needed covering disaster events, social, economic and environmental impacts, socio-economic information, as well as macro-economic information. While some aggregate data is generally made available through PICTs' Bureau of Statistics for monitoring national development goals, including MDGs, these are usually not in a form that could be readily used for vulnerability assessment and to inform advice on climate adaptation policy and strategic actions. More effort is needed to develop linked and harmonised, geo-referenced information system, and associated technical capacity, required to identify context specific hazards, vulnerabilities, and targeted adaptation.

Recommendation 6: *Urgently generate specific baseline information about current and expected trends in natural hazards, population and economic activities, and their sensitivities and develop geo-referenced, harmonised and linked databases using GIS and other modelling tools.*

It is acknowledged that while it may not be possible to build capacity at the national level to undertake such research, at least at the regional level, adaptation strategies must include developing capacity to undertake detailed climate change related vulnerability assessment that brings together, climate predictions ('A'), climate impacts on ecosystems and associated economic systems ('B') and livelihood and economic cost assessment ('C'). While climate change predictions may be national in nature, the impact assessment of climate change on natural, human and economic assets will need to be area and community specific.

Scientific information, together with traditional knowledge, could also be used to develop appropriate adaptation initiatives that are suitable to the local conditions. Adaptation efforts must target economic well being, human health and other determinants of productive humans, including appropriate infrastructure and other enabling environment to support individual decisions, as well as sustainability of natural resource and environment. Adaptation strategies must aim at promoting sustainable livelihoods but may require actions at all levels of government, communities and households. Context-specific adaptation initiatives could be identified using Vulnerability and Capacity Assessment (VCA), which has been used as a key component of disaster risk analysis. Its purpose includes to:

- identify vulnerable groups;
- identify the factors that make them vulnerable and how they are affected;
- assess their needs and capacities (and empower them to assess these); and
- ensure that projects, programmes and policies address these needs, through targeted
- interventions or prevention (PROVENTION Consortium 2006).

VCA considers a wide range of environmental, economic, social, cultural, institutional and political pressures that create vulnerability. Thus sensitivities of key groups to changes in these factors are the focus of attention, maintaining a holistic view. A mixed method and tools suited to the local conditions are used. Analysis is geared to decisions about interventions based on identification of those components of vulnerability that could be tackled cost effectively. Participation of vulnerable people is an essential part of the process, preferably using a consensus-based approach (PROVENTION Consortium 2006).

Limited VCAs have been carried out in the Pacific to identify priority adaptation strategies as well as what is practical. In On Tong Java in Solomon Islands, for example, local residents identified that they were highly vulnerable to the salt intrusion due to sea-level rise, causing saltwater intrusion into the water-table and freshwater aquifer, as well as the destruction of the root crops (Baragamu 2008). Given the limited availability of land on the atoll islands, they realised that very little could be done about the effect of salt water in their garden but they could at least secure rainwater. However, even though the targeted response was the use of water tanks, not every household had access to a water tank to collect rainwater. VCA in selected sites in Solomon Islands also helped communities to work together in risk reduction activities. On the other hand, in Vanuatu, VCA helped the coastal communities on the island of Tengua to identify key risk factors and different response strategies. After careful consideration of the various risk factors and response strategies, relocation was chosen as the most appropriate adaptation response (Nakalevu and Phillips 2007). WWF conducted a V&A for Kabara island in Fiji and through community participation identified locally appropriate adaptation strategies in response to climate change risks (WWF 2008).

Recommendation 7: *Sector level adaptation strategies must initially focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic / oceanographic variability and extremes by targeting improvements in the livelihood assets –financial capital; human capital; socio-political capital; physical capital; and natural capital.*

Recommendation 8: *Adopt a holistic and programmatic approach to understand area and community focused vulnerability, bringing together three categories of knowledge: climate change and climate variability; climate change and climate vulnerability effects on nature, people and economies; and costs to livelihoods.*

Recommendation 9: *Using vulnerability and capacity assessment tool, combine scientific and traditional knowledge to develop adaptation strategies and initiatives, including community level initiatives. These initiatives would focus on sound 'no regrets' approaches and risk reduction initiatives suitable for the local social, economic and socio-political context.*

Recommendation 10: *Strengthen enabling environment – organisational arrangements and decision-making processes – to address cross-sectoral issues at national, sectoral and local levels for climate change adaptation and disaster risk reduction.*

Focus on actors and decision-makers
Considering the multi-dimensional effects of climate change on most aspects of lives and livelihoods, efforts to increase adaptation to climate change will need to focus on actors and decision-makers across and at all levels of society – government policy-makers, sectoral agencies and managers, as well as well as communities and individual households and individuals. Adaptation to climate change has to become everyone's business, and for which good communication, strong advocacy and leadership training will need to be strengthened. The ultimate goal of their actions and decisions is to ensure pro-poor, pro-vulnerable groups develop and improve their basic economic well being, as well as reducing risks and increasing resilience to external shocks and assisting them to sustainably manage their ecosystems and natural resources. Actors and decision-makers also need to be supported by an enabling environment that encourages and facilitates appropriate decisions, thus producing the desired outcomes.

Recommendation 11: *Make climate change adaptation and disaster risk reduction everyone's business through communication, advocacy, and leadership training.*

Recommendation 12: *Develop capacity at all levels of society and across all aspects of livelihoods – individuals, community, sector national development agencies, sectoral managers, and policy-makers – to make informed decision and choices.*

In conclusion, adaptation to climate change is everyone's business. For sustainable adaptation to climate change, there is a need to, amongst other things, pursue pro-poor development strategies as well as the implementation of various sectoral and cross-thematic regional policies agreed to by the Pacific Islands Forum Leaders. Amongst the key regional policies for national level implementation include Disaster Risk Reduction and Disaster Management Strategies and Pacific Island Regional Action Plan on Climate Change.

Given the uncertainty in the scientific knowledge, adaptation to climate change should be treated as a process rather than a prescriptive solution. Adaptation strategies must initially focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic/oceanographic variability and extremes, and which also lay the foundation for tackling future climate change scenarios. Thus, efforts to address climate change effects must be viewed through the lens of improving decision-making process and making evidence based decisions within an adaptive management framework, while making effort to improve the knowledge base (see next for discussion on data).

Furthermore, adaptation by necessity is a context-specific affair and stakeholder based VCA can help identify, prioritise and implement specific initiatives. To successfully address governance issues at all levels and to improve stakeholder decision-making processes, particular attention needs to be paid to institutional and human capacity development. Such initiatives can be guided by key principles and strategies identified in various regional policies and plans of action summarised in Table 19.

Table 19: Principles, themes/objectives of key Regional Policies, Frameworks, and or Plan of Action agreed to by the Pacific Islands Forum Leaders

Regional Policies, Frameworks, and or Plan of Action	Key Principles/ Themes/ Objectives/ Strategies
Pacific Islands Regional Oceans Policy, 2002	Improve the understanding of the oceans Sustainably developing and managing the use of ocean resources Maintain the health of the oceans Promote the peaceful use of the ocean Creating partnerships and promoting cooperation (CROP Marine Sector Working Group 2002)
Natural Disaster Risk Reduction and Disaster Management Framework, 2006-2015	Improved governance – organisation, institutional, policy and decision-making frameworks Improve knowledge, information, public awareness and education Undertake analysis and evaluation of hazards, vulnerabilities and elements of risks Adopt a holistic approach that includes planning for effective preparedness, response and recovery Develop effective, integrated and people oriented early warning system Reduce underlying risk factors
Pacific Islands Framework for Action on Climate Change Implementing adaptation measures, 2005	Improve governance and decision making Improve our understanding of climate change Improve education, training and awareness Contribute to global green house gas reduction Increase partnership and cooperation
Solid Waste Management Strategy, 2005	Develop and implement appropriate waste management infrastructure Develop practical sound and effective waste management policies, legislations and regulations Implement appropriate communication strategies to support effective waste management activities Develop mechanism that are will support waste management in a financially and economically sustainable manner Develop national capacity to assist Pacific Islanders to manage their waste in an environmentally sustainable manner
Pacific Wastewater Framework for Action, 2002	The Policy Statement addresses issues of: • national policy, regulation and enforcement • institutions, infrastructure and information; • finances; • staffing and training; and • community involvement
Pacific Regional Action Plan for Sustainable Water Management (Pacific RAP), 2003	Water Resource Management – Water Resource Assessment and Monitoring; Rural Water Supply and Sanitation; Integrated Water resource Management and Catchment management Island Vulnerability – Disaster preparedness; Dialogue on Water and Climate

VI. Data Requirements

Climate change is a multi-faceted and dynamic phenomenon for which information needs to be drawn from different sectors to address specific adaptation issues. Baseline information is very limited at best and almost non-existent particularly when socioeconomic information and data for determining economic cost of climate change are concerned. Disaster information is restricted to the Emergency Disasters Database (EMDAT) (which can be accessed through their website http://www.emdat.be). It reports only intensive disasters, where at least 10,000 people are affected. Given the population distribution in the Pacific, this rules out many of the normal climate-related disasters. Also the national data system on hazards is limited to post-disaster assessments for basing the disaster response and rehabilitation programmes on. National disaster management offices maintain some disaster-related information, including impact assessments, although these are not complete and what is collected is not available in a form that can be readily accessed.

Much of the primary data about population is available from census data but in many cases these are not geo-referenced, or readily accessible by disaster managers. Some household income and expenditure survey data is available, but these are usually outdated, are not geo-referenced or can easily be extrapolated to other areas. Broad aggregate level information is reported against national development goals, including MDGs, making it difficult to do the types of analyses required for climate change adaptation. Specific time series meteorological data is often available from either national meteorological services or at the regional level through the places such as Nadi Meteorological Services, NZ Meteorological Service and Australian Bureau of Meteorology.

Availability of specific information in the Pacific is variable and scattered across different agencies. Different data sets were historically developed for own departmental, sectoral or thematic use. Some of the information is also available from regional governmental agencies, such as SOPAC and SPC.

In an effort to increase access to the material needed for decision-making, SOPAC, in collaboration with its Pacific Disaster Risk Management Network, recently launched a Pacific Disaster Net database that can be accessed online (Box 11).

Box 11: Pacific Disaster Net

The Pacific Disaster Net is the "virtual centre of excellence" for disaster risk management in the Pacific region. The Web portal and database system is designed to be a comprehensive information resource in relation to disaster risk management for Pacific Island countries. It is a living collection of information on international, regional and country information covering topics such as governance, risk assessment, early warning and monitoring, and risk reduction.

The information is in a range of formats including reports, data inventories, maps, contacts, web links, etc. The portal aims to provide different but simple and intuitive ways to search for relevant information.

Information from the portal can be viewed, downloaded, sent by email and even exported into other formats. For interactive use there are different levels of access to a variety of issues. A country page provides filtered, dynamic and fixed data and information with events, contacts, links and basic facts – available per country, organisation, etc.

Source: http://www.pacificdisaster.net/pdn2008 (accessed 15 December, 2008)

This database provides an excellent source for information that may be published or exists as grey literature. However, this is but a first step. Concerted effort is needed to develop a robust and harmonised country-specific empirical national information system, which can also be used for vulnerability assessment to underpin targeted adaptation to climate change. Several different types and layers of information are needed to support adaptation to climate change. These include:

Weather and sea level data

- Metereological data; and
- Sea level Monitoring data.

Hazard assessment

- Historical trend data on past extensive and intensive disasters;
- Predictive climate change models; and
- Geo-referenced hazards maps and hazard 'hot spots'.

Household distribution sensitivity

- Geo-referenced population distribution and socioeconomic characteristics;
- Geo-referenced health statistics, economic well being and human well being statistics; and
- Household sensitivity to disasters, measured by proxy indicators of household wellbeing, including household income, diversity of livelihood, information about access to water, sanitation, status regarding hardship.

Natural capital sensitivity

- Broad and specific reports on the status of ecosystems, such a coral reef, mangroves, coastal shoreline;
- Stress on natural ecosystems from human activities; and
- Trends in the use and management of natural resources.

Vulnerability assessment

- Household vulnerability assessment, combining scientific hazard information, expected local damage functions, and household and community level sensitivity; and
- Geo-referenced vulnerable groups.

Context specific adaptation measures

- Traditional adaptation measures; and
- Adaptation options for improving food and income security; sustainable; livelihood, improvements in basic social well being, including access to secure water, improved sanitation, medical services and communication.

Macroeconomic data

- Key macroeconomic indicators; and
- National Budget and government financing.

Recommendation 13: *Urgently develop harmonised and geo-referenced national information system covering livelihood assets – natural, human, financial, and physical capital – that can be used to identify sensitivities to climate change, adaptive capacity, and key strategies covering pro-poor development, natural resource and environmental management and disaster risk reduction and disaster management.*

VII. Conclusion

PICTs are already experiencing the effects of climate change, even if the economics and social costs are poorly understood. Detailed analysis into the economics of climate change is limited and partial. A relatively larger number of 'with and without' impact analysis of natural disasters, many of which are climate-related, have been undertaken in the region. These, too, are still smaller in numbers and scope compared to studies completed for other SID regions.

For the Pacific, climate change is a development issue, placing increased pressures on already limited capacity to meet the needs and aspirations of the region's people and improve basic livelihoods. The real challenge in the region is what individually and collectively can be done to minimise vulnerabilities of the individuals, communities, economies and environment to the effects of climate change.

Adaptation to climate change is everyone's business, and must involve actors and decision-makers at all levels of government and communities. Adaptation must be context-specific reflecting expected local hazard conditions, the status of environmental, social, economic capital and human capacity.

To achieve this, many focused and targeted initiatives are relevant, including climate change, and disaster risk management, being mainstreamed into national planning and budgetary processes as well as sectoral-level decision-making processes, placing PICTs in the driver's seat. Mainstreaming will also help countries to adopt systematic and programmatic approach that can help guide countries' own efforts, as well as seeking coordinated and harmonised development partners assistance to complement their own initiatives. Climate change adaptation must target specific sensitivity areas as well as coping mechanisms to climate change effects, and translate these into actions that people can adopt to reduce their risks, but also increase their capacity to respond and cope with climate change effects.

Acknowledging that capacity is low and information is limited, including baseline data to make informed decisions, countries must focus on sound 'no regrets' approaches which initially seek to build resilience to existing known climatic/oceanographic variability and extremes, and which also lay the foundation for tackling future climate change scenarios. Appropriate governance arrangements must be put in place that encourages the cross-cutting nature of climate change issues to be appropriately addressed. Thus, efforts to address climate change effects must be viewed through the lens of improving decision-making process and making evidence-based decisions regarding national development and livelihood as well as resource and environmental management within an adaptive management framework. Simultaneously, every effort needs to be made to improve the knowledge base.

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Annex 1

Review and assess socio-economic impacts of climate change

The consultant will undertake a review of existing studies on socio-economic costs and benefits of climate change and variability impacts on coastal and marine ecosystems (i.e. increased temperature, sea-level rise, ocean acidification, etc.) focusing on livelihoods and selected economic sectors (e.g. subsistence fisheries and agriculture, commercial fisheries, tourism, etc.) and ecosystems services (e.g. coastal protection, beach replenishment) in Melanesia and comparable small islands developing states (SIDs) context.

- Describe impacts of predicted climate changes on existing land and marine based activities and livelihoods;
- Compile existing information on costs of climate change and variability to those sectors;
- Evaluate relative vulnerability and sensitivity of those sectors to climate change impacts, taking into account global regional and local drivers;
- Identify key vulnerability and resilience factors and propose solutions to strengthen socio-economic resilience;
- Propose key socio-economic variables (and datasets as available) that could be included in a spatially derived vulnerability assessment to provide guidance to policy makers on re silience (e.g. land use, settlement, etc.);
- Identify knowledge gaps and propose a programme of work to improve the information; and
- Prepare a report for peer review, including a short plain English summary version of the report, highlighting the key results of the review.

Annex 2

List of persons consulted in Vanuatu and Solomon Islands

a) People consulted in Vanuatu

Name	Position	Organisation
Adele Issachar	Research Officer	Department of Tourism
Anthea Toka	Manager	OXFAM
Augustine Garae	Disaster Officer	Vanuatu Red Cross
Benjamin Jesse	Managing Director	Energy Unit
Brian Phillips	Coordinator, NACCC	Meteorology Department
Catherine Malosu	Environment Officer	Millennium Challenge Account
Donald Douloige		Civil Aviation
Francis Hickey		Vanuatu Cultural Commission
George Kanegal		Department of Agriculture
George Petro	Marine Species Officer	Wan Smol Bag
George Taleo	Vector Borne Disease Manager	Public Health Department
Henry Vira	Secretary General	VANGO
Iona Viji		Department of Forestry
Jason Raubani	Policy Officer	Department of Fisheries
Jerry Samson		Department of Provincial Affairs
Jo Dorras	Managing Director	Wan Smol Bag
Job Esau	Managing Director	Ministry of Disaster Management
Jocelyn Loughman	Manager	World Vision
Joe Lautu	Travel/Trade Officer	Vanuatu Tourism Office
Jotham Napat	Managing Director	Meteorology Department
Leah Nimoho	Small Grants Officer	UNDP GEF
Mathew Temar	GIS Officer	Department of Lands
Myriam Abel	Director General	Ministry of Health
Nelly Wouloseje	Water Quality Officer	Public Health Department
Pakoa Rarua	Waste Management Officer	Public Health Department
Patrick Haines	Operations Manager	AusAID
Pita Toa	Senior Statistician	National Statistics Office
Rachel Young	Secretary	AusAID
Ralph Regenavu	Director	Vanuatu Cultural Commission
Russell Nari	Director General	Ministry of Lands, Geology, Mines, and Environment
Shirley Laban	Food Safety Officer	Public Health Department
Simil Johnson	Acting Government Statistician	National Statistics Office
Tony	Director	Millennium Challenge Account
Trinison Tari	Managing Director	Environment Department
William Ganileo	Land Management Officer	Department of Lands
Yvanah Taga	Health Information Officer	Ministry of Health

b) People consulted in the Solomon Islands

Name	Position	Organisation
Agnetha Vave Karamui	Senior Environment Officer	Conservation Division - MECM
Alex Makini	Lecturer	School of Natural Resources - SICHE
Bernard Bakote'e	Director	Solomon Islands Medical Training and Research Institute
Chanel Iroi	Under Secretary	Ministry of Environment, Conservation and Meteorology (MECM)
Charlie Bepapa	Director	Water Resources Division
Connely Sandakabatu	Head of School	School of Natural Resources – SICHE
Douglas Yee	Director	Climate Change Division, Ministry of Environment, Conservation and Meteorology
Douglas Kauhiona	Climate Change Officer	Climate Change Division, Ministry of Environment, Conservation and Meteorology
Dr Graham Sem	NAPA Consultant	Private Consultant
Dr Mick Saito	Environment Manager	UNDP – Honiara
Dr Steve Aumanu	Private Medical Doctor	Panatina Medical Centre
Elizabeth Ragimana	Senior Officer	Development Bank of Solomon Is
Ella Kauhue	General Secretary	National Council of Women
Fred Siho	Chief Field Officer	Environment and Conservation Division – MECM
Gabriel Hiele	Project Officer	Department of Agriculture and Livestock
George Baragamu	Senior Officer	Solomon Is Red Cross
Gordon Konairamo	Commissioner of Forests	Department of Forestry
Hon. Gordon Darcy Lilo	Minister	MECM
Inia Barry	Officer in Charge	Solomon Islands Kastom Gaden Association
Jack Filiomea	Principal Officer	Environmental Health
Jean Qalo	Senior Field Officer	Department of Agriculture
Josef Hurataran	Senior Field Officer	Conservation Division, Ministry of Environment, Conservation and Meteorology
Julian Makaa	Communications Officer	Disaster Management Office
Julie Webb	Officer	Solomon Islands Red Cross
Jimmy Saelea	Director of Research	Department of Agriculture
Loti Yates	Director	Disaster Management Office
Moses Pelomo	General Manager	Commodities Export Marketing Authority
Nesta Leguvaka	Coordinator – 2nd National Communications Project	Climate Change Division, Ministry of Environment, Conservation and Meteorology
Agnetha Vave Karamui	Senior Environment Officer	Conservation Division, Ministry of Environment, Conservation and Meteorology
Alex Makini	Lecturer	School of Natural Resources – SICHE

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The world is expected to experience increased climate variability as well as extreme weather events, such as prolonged drought, heavy rains and heat waves, and the increased frequency and intensity of tropical cyclones. Sea level rise is also predicted.

The effects of such changes will be significant to all the Pacific Island countries and territories (PICTs), although the nature and degree of the socioeconomic impact of climate change cannot be predicted with any certainty at this point in time.

This Melanesia project is part of a John D. and Catherine T. MacArthur Foundation initiative to help understand better adaptation strategies suited to local circumstances, which are based on local information, good governance and through the strengthening of conservation practices.