The DCCEE-IUCN project: assessing the social and economic value of climate change adaptation in the pacific region

Case study: water quality, quantity and sanitation improvements as an adaptation to climate change, Tuvalu – a preliminary assessment

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Glossary

Climate change – A change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability, observed over comparable time periods (UNFCCC 1994).

Climate change adaptation – The adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities (UNISDR, 2009).

Consumer price index – A price index covering the prices of consumer goods used to indicate the national level of inflation.

Discounting – The process of removing the time value of money from future cash flows.

Discount rate – The rate that is used to bring a series of future cash flows to their present value to reflect the lower weight placed by people on income earned in the future as compared to what can be earned today. Use of a discount rate removes the time value of money from future cash flows.

Greenhouse gases – gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation (UNFCCC, 1994).

Present value – The sum of discounted costs or discounted benefits over a given period of time.

Net present value – The difference between the present (discounted) value of benefits and the present (discounted) value of costs.

Storm surge – A rise above the normal water level along a shore caused by strong onshore winds and/or reduced atmospheric pressure. The surge height is the difference of the observed water level minus the predicted tide (Weatherbug 2011).

'With' scenario – A dynamic situation over time with an intervention taking place.

'Without' scenario – A dynamic situation over time without an intervention taking place.

Acronyms

ACP	African, Caribbean and Pacific group of states
CBA	Cost-Benefit Analysis
CCA	Climate Change Adaptation
COP	Conference of the Parties
DCCEE	Department of Climate Change and Energy Efficiency
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ENSO	El Niño Southern Oscillation
EU	European Union
GAR	Global Assessment Report for Disaster Risk Reduction
GEF	Global Environmental Facility
GFDRR	Global Facility for Disaster Risk Reduction
HFA	Hyogo Framework for Action
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
IWP	International Waters Programme
IWRM	Integrated Water Resources Management
LDC	Least Developed Country
NAP	National Action Plan
NAPA	National Adaptation Programme of Action
NSDS	National Sustainable Development Strategy
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific regional environment Programme
PACC	Pacific Adaptation to Climate Change
PASAP	Pacific Adaptation Strategy Assistance Programme
PIC	Pacific Island Country
PIFACC	Pacific Islands Framework for Action on Climate Change
RFA	Regional Framework for Action
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction

Executive Summary

In 2010, the United Nations declared water and sanitation a human right due to their importance for life, health, dignity, empowerment and prosperity. The Pacific region confirmed its commitment to this and numerous strategies and plans have been developed through the region to support the targeting of water and sanitation for human development.

Despite this interest, the Pacific remains the only region in the world to be measured as not progressing positively in water and sanitation goals. The Pacific proportion of population with access to safe drinking water and sanitation facilities has reportedly declined by one per cent and two per cent, respectively (UN-WATER 2007).

The Pacific island country of Tuvalu faces ongoing challenges in its water security. A series of atolls, the permeable nature of its land means that surface water does not exist and families rely heavily upon rainwater for supplies. The water lens below the main island of Funafuti provides an emergency source of water for washing during droughts but is too saline for human consumption. When rainwater is scarce, the island also draws on reserves in the form of desalinated water but this is expensive. Access to sufficient clean rainwater is therefore, key to survival and human development. However, in the face of climate change, variability of rainfall increases concerns about the future supply of water on the island. In the face of these conditions, numerous water projects are implemented on the main island of Funafuti.

The Australian Government is implementing the Pacific Adaptation Strategy Assistance Programme (PASAP), under its International Climate Change Adaptation Initiative programme in Asia-Pacific. The PASAP is intended to strengthen partner country capacity to assess vulnerability to climate change and develop evidence-based adaptation strategies. A key element of the PASAP is to conduct a regional overview that describes regional trends and variability in climate change impacts, vulnerability and adaptive capacity, and identifies common needs.

To contribute to this overview, IUCN (International Union for the Conservation of Nature) is undertaking an economic study to *assess the social and economic values of climate change adaptation projects in the Pacific.* The goal in the IUCN study is to contribute to the development of an analytical framework to assess the social and economic value of climate change adaptation in the Pacific region in the context of national development.

This document represents a contribution to the IUCN study, outlining an economic assessment of three water projects presently underway in Tuvalu that may have application for climate change in the future. These three projects considered are:

- the SPREP - executed GEF PACC project;
- the SOPAC - executed EU B-Envelope Disaster Risk Reduction project; and
- the SOPAC - executed GEF Pacific Integrated Water Resources Management (IWRM) project.

All three projects target improved water security in Tuvalu. The SPREP-executed GEF PACC project aims to improve the resilience of water resources on Funafuti by improving water resource management and enhancing the adaptive capacity of communities and socio-economic activities to climate change and sea level rise. It includes activities such as rainwater collection schemes, the development of a guide for climate proofing existing water reservoirs and water tanks, as well as education and awareness.

The SOPAC-executed IWRM project aims to reduce the vulnerability of Tuvalu to drought and improve human health through improved waste water management in an IWRM framework. The project includes activities to improve rainwater harvesting, improve sanitation infrastructure through demonstration of composting toilets and regular sanitation workshops, as well as support water demand management (e.g. leakage control).

The SOPAC-executed EU-B Envelope project aims to improve the resilience of the Funafuti community to drought and provide access to safe drinking water, focusing on Funafuti. Project activities centre on the provision of rainwater catchment systems for households and communities, improved distribution of freshwater, improved sanitation and training and awareness to maintain rainwater catchments and manage water usage.

Combined, the three projects should contribute to an increase in water quality available, increased availability on Funafuti of potable water and reduced demands on that water.

Analysis of the three projects was conducted from two perspectives:

- an assessment of how the projects were designed to address drought risks of the community on Funafuti
- assessment of the potential economic contributions of projects (cost benefit analysis)

Assessment of project design was conducted from the perspective of a project cycle, considering steps in project identification and preparation, appraisal, implementation and monitoring. On the matter of project identification and preparation, all projects addressed the national priority of water supply and/or quality. Some identified project activities on the basis of diagnostic analysis while others identified activities on the basis of consultations supported by surveys. In some cases, lack of access to documentation at the time of this study prevented assessment of how some survey information informed projects.

All projects conducted some forms of appraisal although they did so differently. Unfortunately, lack of access to produced documentation hindered assessment of the process in some cases. In some cases, documents were still in preparation but were not available at the time of project assessment. In other cases, no documents could be accessed. What is clear is that no economic assessment of projects was conducted prior to implementation to inform project direction – although such ex-ante application of economic analysis of projects is not common in the Pacific so this is not a surprise.

All projects are subject to stringent monitoring and report as part of project design and accountability to donors. Possibly, due to a lack of baseline data, monitoring of projects was dominated by the use of process indicators – indicators of what has been done rather than

their impact. Given that the impact of much of project activity was related to behaviour change, this is not surprising. Information on the direct impact on one project (EU-B-Envelope) on water supply was, by comparison, accessible.

For the most part, the three projects appear to target enhancing the resilience of the local community to threats, acknowledging the vulnerability faced by the community and working to address local priorities. Possibly due to the lack of baseline data, the projects appeared not to be designed to address specific projected changes in water security conditions but rather increase the resilience (reduce the vulnerability) of the community to existing threats in the fact of climate change.

The economic analysis of the projects was conducted, using a cost benefit framework. Given that the three projects target similar and complementary activities, it was not practical to attempt to distinguish the impacts of one project compared to another. Rather, an analysis of the potential projects of all three projects was combined. Additionally, since all projects are still underway, the assessment is an estimate of potential benefits from the projects into the future.

The likely impacts of the projects – if successful – would occur through an increase in access to potable water (improved water quantity and quality). This would be expected to lead to improved health (reductions in water borne disease), a reduction in days lost at work, as well as reduced pressure on the government and families to purchase water. Attempts were made to value these benefits. Other benefits – such as improved ecosystems in the near shore area, reduced trauma from chronic illness, reduced stress or improved water use efficiency in the future – are also possible. However, efforts were not made to value these benefits on the grounds of limited data.

On the basis of data available, the expected pay off from the three projects over a 20-year time frame was estimated to be in the order of 1.8:1, that is, a saving of almost AU$2 for every dollar invested in the projects. These benefits are not definite as health benefits could potentially be overestimated while many benefits from the projects are certainly underestimated. For example, the potential benefits from the establishment of communal tanks have not been valued, nor the long-term impact on sanitation practises gained from the use of demonstration composting toilets. Additionally, the estimates do not estimate the value of benefits from a range of other factors, such as the value of improved coastal ecosystems and fishing opportunities, any reduction in chronic health problems and reduced stress. Critically, no estimate is made of the value of benefits associated with activities inspired by the projects. This is important since some of the projects are intended to catalyse other projects and act as demonstrations of the value of specific activities.

The estimation of economic pay off was hampered by a lack of information. In many cases, documents relevant to the assessments of the projects were not available. In other cases, information critical to assess project impact (baseline data) was unavailable. For example, information on the number of hospital patients that suffered from waterborne disease did not reveal whether patients had become sick from water on Funafuti or elsewhere. Consequently, it was difficult to estimate with certainty the number of people likely to

benefit from the projects. Additionally, it is difficult to predict the likely impact of education and awareness work on water quality and quantity in the future.

To accommodate these data gaps, assumptions were made throughout the assessment, essentially generating scenarios of how projects would improve the quality of life on Funafuti. The resulting values can therefore only be considered preliminary and indicative.

Sensitivity analyses were conducted around these assumptions and indicate that assumptions about the impact of water projects on health are most critical to expected payoffs.

Despite the data gaps and the need to project scenarios, economic analysis of the projects remained valuable to indicate the kinds of parameters that might be monitored in the future when implementing projects and to consider the factors on which project success relies. For example, it becomes apparent when considering the pay off of projects that project benefits will be affected by the level of post-project support provided by the community and/or government to activities. For instance, new water tanks will require ongoing maintenance to ensure that guttering is functional and that tanks are kept clean. Without this, it is probable that water quantity saved and quality achieved will dwindle over time.

In the future, the potential benefits offered by the three specific projects considered might be enhanced. This might be achieved through heightened awareness and communication of how the projects interact. At present, project managers emphasise the degree to which some of the projects support and co-fund each other's activities and yet, understanding of this is not apparent to all stakeholders. Criticism of project coordination could be avoided with improved communication. In any event, such communication might be enhanced by the introduction of a Water Coordination body to ensure the full flow of information.

In the same vein, the potential benefits of the project might be better understood if there was increased communication and public documentation on the rationale for the design of some aspects of projects. As an example, public rationale for the location or design of a community water cistern in one of the Funafuti villages would allay concerns about its appropriateness.

Finally, improved baseline information would, in the future, enable more targeting, monitoring and assessment of project impacts which would provide empirical evidence of the contribution of the projects to community wellbeing. This would also be expected to have value to donors. Identification of critical baseline data – at least from a socioeconomic stand point – might be facilitated if even a theoretical economic analysis of proposed solutions is conducted before project implementation.

Chapter 1 Background

> *"With weakening prospects of prompt mitigation, it is increasingly likely that the world will experience 4°C and more of global warming. In such a world, adaptation decisions that have long lead times or that have implications playing out over many decades become more uncertain and complex" (Stafford Smith et al. 2011).*

1.1 Introduction

Climate change is a key challenge of our time for two reasons. First, it is an important phenomenon whose consequences occur on a global scale, affecting a broad range of factors such as standards of living and environmental security of all human communities. The cumulative economic impact of climate change is therefore, predicted to be high: *under a business-as-usual scenario, Stern (2007)* predicts climate change to reduce global Gross Domestic Product (GDP) by between 5 and 20 per cent each year. Second, the policy package required to tackle climate change is extremely complex and has profound socioeconomic consequences. According to the World Bank, global adaptation to a 2°C is predicted to cost between US$75 and US$100 billion per year between 2010 and 2050 (UNWWAP 2008). Suggested policies to address climate change-related problems include low-carbon development, based on new energy production and consumption. Quite simply, climate change and the global policy response to the problem will reshape our world (Dimitrov 2010).

According to the IPCC (2007), climate change due to fossil-fuelled economic and social development will likely cause:

- temperature rise;
- sea level rise;
- precipitation change; and
- droughts and floods.

The IPCC (2007) also suggests that the risks associated with these climate change impacts include:

- increased insecurity of food and water resources;
- damage to ecosystems and biodiversity; and
- negative effects on human settlements (e.g. displacement) and human health (e.g. illness).

In the face of climate change and the risks it generates, the Australian Government is implementing the Pacific Adaptation Strategy Assistance Programme (PASAP) under its International Climate Change Adaptation Initiative programme in Asia-Pacific. The PASAP is intended to strengthen partner country capacity to assess vulnerability to climate change and develop evidence-based adaptation strategies. A key element of the PASAP is to conduct

a regional overview that describes regional trends and variability in climate change impacts, vulnerability and adaptive capacity, and identifies common needs. The overview will synthesize existing knowledge about adaptation in the region, identify lessons learned, relevant good practice and significant knowledge/research gaps.

To contribute to this overview, IUCN is undertaking an economic study assessing the social and economic values of climate change adaptation projects in the Pacific: strengthening knowledge-based climate change adaptation. The goal in the IUCN study is to contribute to the development of an analytical framework to assess the social and economic value of climate change adaptation in the Pacific region in the context of national development.

The IUCN study will:

- assess how the economic and social impacts of climate change and climate change adaptation are currently considered in making informed decisions at national, sub-national and community levels in the Pacific;
- identify constraints in the use of social and economic assessment of climate change impacts of adaptation options, including consideration of the social and economic realities of the Pacific;
- provide appropriate analytical frameworks to inform decision-making on adaptation options which are relevant and effective in the specific biophysical, social and economic realities of the Pacific Island Countries (PICs); and
- suggest priorities for strengthening PIC capacity to explicitly assess and utilize economic and social valuation of options to make informed decisions about climate change adaptation.

The IUCN study will reflect components/lessons learned from selected international and regional literature, as well as detailed analysis of selected case studies that describe climate change-relevant activities in several key sectors: food security, infrastructure, water security and health, and coasts and nature-based solutions. With regards to the regional literature on water security and health, several costs and benefits associated with water-related issues have already been identified. Examples of water-related costs that have already been assessed in the Pacific include:

- the IWP study conducted in Funafuti, Tuvalu in 2006, which revealed the annual cost of AU$500,000 being incurred by a largely ineffective septic-tank wastewater system (Lal at al. 2006.);
- work by Hajkowicz et al. (2006) in which the best estimate of the healthcare costs of solid waste-related pollution in Palau amounted to around US$669,000 per year; and
- an economic study conducted by Gerber (2010), recording total benefits of US$1.34 million (over a 20-year time period) for the Drinking Water Safety Plan in Koror-Airai, Palau.

The remainder of this document outlines in detail the water security and health case study that the IUCN will consider in its work. This case study will provide an economic analysis of three sanitation and water-security projects in Tuvalu that have relevance to climate change adaptation:

- SOPAC/SPC (Secretariat of the Pacific Community Applied Geosciences and Technology Division)-executed GEF IWRM project;
- SPREP (Secretariat of the Pacific Regional Environment Programme)-executed PACC project; and
- SOPAC/ Secretariat of the Pacific Community (SPC)-executed European Union funded Disaster Risk Reduction project.

Based on the analysis, lessons learned in adaptation will be identified and the implications of these for the application of future sanitation and water security adaptation projects considered. The analysis of water case studies in Tuvalu has been executed by SOPAC/SPC. It considers the factors used to design the projects, their implementation and, ultimately, their contribution to social well-being. On the basis of lessons learned, an analytical framework to develop climate change adaptation projects in the sanitation and water security sector will be identified.

1.2 Purpose

This document will examine three selected climate change projects from a socioeconomic perspective. The assessment will consider institutional issues in the design and implementation of projects as well as the successfulness of each project in providing a solution to its problem statement and the potential economic contribution of each project to the national economy. It is anticipated that this analysis will inform the design and implementation of future climate change adaptation projects in the Pacific. This analysis includes:

- project identification and consultation procedures involved;
- extent to which household water needs, climate change, economics and environmental impact assessment were part of the planning stages;
- project activity development and the ability of activities to match and resolve the identified problems; and
- project implementation.

The main focus of the three projects that progress climate change adaptation is on:

- improved water security by increasing the quantity of clean water provision and reducing the amount of freshwater resources used for sanitation; and
- improved human health through improved rainwater quality and reduced contamination of safe drinking water with polluted water sources.

This study has been commissioned by IUCN who will use the findings to inform its economic study "Assessing the social and economic value of climate change adaptation in the pacific region: strengthening knowledge-based climate change adaptation."

1.3 Activities undertaken and timeline

Activities undertaken, as requested by and agreed with DCCEE are summarized in Table 1 in Annex 2.

Chapter 2 Introduction

Pacific island countries are among the most natural hazard prone countries of the world, with key natural hazards, including earthquakes, tsunamis, volcanic activity, landslides, cyclones, drought and flooding. Bettencourt et al. (2006, Table 1) observes that over 90 per cent of reported disasters in the Pacific since 1950 could be accounted for by climatic risks.

Table 1 Reported disasters in Pacific island countries (1950 – 2004) (2004 US$M)

	Number	Reported Fatalities	Population Affected*	Reported Losses (in 2004 US$ Million)
Windstorms**	157	1,380	2,496,808	$5,903.90
Droughts	10	0	629,580	$137.00
Floods	8	40	246,644	$94.80
Earthquakes	17	53	22,254	$330.60
Others***	15	274	21,520+	$60.00
Melanesia ****	110	1,130	2,115,332	$1,654.90
Polynesia	71	494	1,041,012	$1,797.40
Micronesia*****	26	123	260,662	$3,074.04
Total Pacific	207	1,747	3,417,006	$6,526.30

Notes:

* Fatalities plus total population affected. All data excludes PNG.

** Cyclones, tidal surges and storms.

*** Landslides, tsunamis, volcano eruptions, wild fires and epidemics.

**** Data for Melanesia does not include PNG.

***** Data for Micronesia is strongly influenced 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: Bettencourt et al. 2006 (citing data from: EM-DAT: the OFDA/CRED International Disaster Database for 1950–2004 data and adjusted by SOPAC for 1994–2005 data).

While the existence of natural hazards does not in and of itself cause disasters, developing Pacific island countries are nevertheless vulnerable to disasters as a result of their relatively low capacity to deal with hazards, which is related to high rates of poverty, isolation and often rapidly changing socioeconomic conditions. Subsequently, climate change can potentially worsen the exposure of Pacific island countries to disasters, and generate the need for adaptation to reduce the cost of climate change-related disasters.

2.1 Global issues in disaster risk management

According to the United Nations International Strategy for Disaster Reduction (UNISDR) (2009), a hazard is a condition that may cause loss of life, injury and health impacts, property damage, loss of livelihoods and services, social and economic disruption, and/or environmental damage. Hazards can arise from geological, meteorological, hydrological,

oceanic, biological or technological features (UNISDR 2005). In the Pacific, key causes of natural hazards include the proximity of the Pacific island countries to the Pacific 'Ring of Fire', a nearly continuous series of oceanic trenches, volcanic arcs, volcanic belts and/or plate movements surrounding the islands in the Pacific and contributing to tsunamis and volcanic eruptions. Concurrently, warm moist air from the Pacific Ocean can cause cyclones and storms; and, alterations in the Inter-tropical Convergence Zone and the South Pacific Convergence Zone can result in variations in precipitation, leading to floods and droughts (see Bardsley and Vavae 2009).

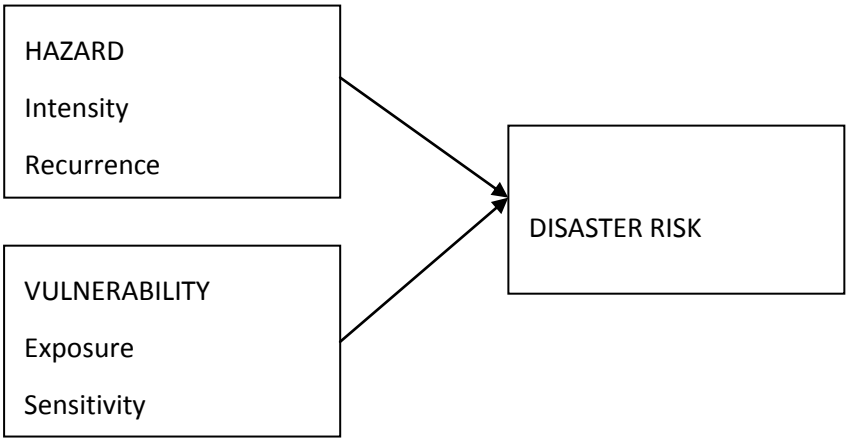
The frequency and intensity of natural hazards, including their speed of onset, duration and intensity affect the scale of damage potentially incurred.

The UNISDR (2009) defines a disaster as a disruption to the functioning of a community that exceeds the ability of that community to cope (see UNISDR 2009 for details). Where a community is not vulnerable, a hazard event therefore, need not cause a disaster. UNISDR (2009) defines 'vulnerability' as the characteristics and circumstances of a community, system or asset that makes it susceptible to the damaging effects of a hazard. Vulnerability reflects a number of features in a community including, exposure, fragility and sensitivity (see Lal et al. 2009). Exposure reflects the people, property or other elements that are present in a hazard zone, for example the types of assets or the number of people that are in a specific area (ISDR 2009). According to Benson (1997) and Lal et al. (2009), sensitivity reflects individuals' and communities' conditions that have the potential to magnify the effect of disaster – for example, with regards the types of industries that are relied upon for livelihood, Lal et al. (2009) claim that Pacific island countries that are heavily reliant on the primary sector are more sensitive to the effects of natural disasters.

Combined, these elements that make up community vulnerability can be linked to the structure and the status of the national economy, the condition of physical infrastructure (including access to water and sanitation) and the socioeconomic characteristics of households (including income, health and education) (Lal et al. 2009). Overall, vulnerability explains why, with a given level of physical exposure, some people are more at risk of disaster than others (see UNISDR 2009). To this end, UNISDR (2009) observes that it is a country's lack of resources to deal with a hazard that turns it into a disaster.

Combined therefore, hazard and vulnerability determine the level of disaster risk that a community faces (Figure 1).

Figure 1 Disaster risk



2.2 Climate change

In addition to naturally occurring hazards, increased frequency and severity of hazards may arise as a result of climate change. Climate change is defined as the process involving significant alterations in the global energy budget, where this budget is initially generated by incoming solar radiation. These changes then cause lasting changes in the statistical distribution of weather patterns over periods ranging from decades to millions of years. This may manifest itself in a change in average weather conditions or, indeed, in the distribution and severity of weather events.

Climate change occurs as a result of rising greenhouse gas emissions which accumulate in the earth's atmosphere, generating a number of environmental imbalances (IPCC 2007). In addition to worsened storms, Allison et al. (2009) state that the effects of climate change are manifested as:

- **global temperatures warming:** Over the past 25 years, temperatures have increased at a rate of 0.19°C per decade. Natural, short-term fluctuations are occurring as usual, but there have been no significant changes in the underlying warming trend;
- **acceleration of melting of ice-sheets, glaciers and ice-caps**: Both the Greenland and Antarctic ice-sheets are losing mass at an increasing rate. Melting of glaciers and ice-caps in other parts of the world has also accelerated since 1990; and
- **sea level rise**: Although estimates vary across the literature, sea level could rise by about two metres by 2100. Sea level will continue to rise for centuries after global temperatures have been stabilized, and several metres of sea level rise could, theoretically, occur over the next few centuries.

In this respect, climate change can be seen to increase the threat of hazards that countries around the world face. Thus, the United Nations Framework Convention on Climate Change (UNFCCC) (2007) observes that climate change has contributed to increased intensity of hurricanes, droughts and other weather phenomena (IPCC 2007). Likewise, Collins et al. (2010) suggest that, in line with the IPCC (2007) report, climate change will likely modify the

El Niño Southern Oscillation (ENSO) – a quasi-periodic natural phenomena occurring, on average, every five years across the Pacific Ocean. ENSO causes prolonged sea surface temperature differences across the Pacific Ocean when compared with the average value; other effects influence trade winds, air pressure and precipitation. These temporary climatic changes cause more extreme hydro-meteorological phenomena. Given that that ENSO variability is responsible for much of the hydro-meteorological activity in the Pacific, if this mechanism is affected by climate change, it will likely have implications for Pacific island countries.

While climate change has implications for the occurrence of hazards, it can also contribute to disaster risk by increasing the vulnerability of communities to disaster. For example, climate change has the potential to decrease crop yields, increase the incidence of disease vectors such as mosquitoes and/or affect the resilience of housing in the face of climate change-induced sea level rise. In the Pacific, the threat of climate change exists in the way that climate change can affect water security by causing droughts, and water quality which consequently affects water-related health. Concerns exist about the potential of climate change to increase drought and thereby negatively impact health through decreased access to safe water (IPCC 2007). To this end, Singh et al. (2010) suggest that climate change will have a devastating impact on health, notably in the Pacific. This would then reduce the ability of any given community to cope with the additional pressure from a hazard event, such as a flood or a storm surge.

With regards to climate change and disasters, GFDRR (2006) suggest that, between 1991 and 2005, climate-related disasters were responsible for 98 per cent of the cumulative number of people affected by natural disasters and for 77 per cent of total reported economic damage.

Climate change and Pacific water security issues

Globally, the GFDRR (2006) suggest that the developing world depends on climate-sensitive sectors, such as agriculture and fishing – in the Pacific, specifically (GFDRR 2006). The potential losses involved in the Pacific are compounded by the fact that data gaps make it difficult for Pacific island countries to adequately plan adaptive responses and conduct risk management activities. Finally, Pacific island countries that are increasingly vulnerable to climate-related disasters are also increasingly vulnerable to climate-related illnesses, such as diarrhoea (IPCC 2007; Singh et al. 2010.)

Globally, concerns in the water sector reflect the need to ensure access to sufficient safe water, ensuring a high enough quantity of water and ensuring its quality is maintained. In the Pacific, climate-related problems related to water security range from flooding, where rainwater becomes abundant in a very short period, to drought, where rainwater is unusually scarce for a long period. In some regions, such as in Nadi, Ba and Navua in the Fiji Islands, slow-moving depressions and heavy rainfall may cause flooding in low-lying areas and consequent contamination of water cisterns and rainwater tanks with surrounding leaking septic tanks or other contaminants. In other regions, usually in atoll nations where groundwater is limited and rainfall is irregular, scarcity of water altogether ensues. Other threats to water security can come in the form of the pollution of the limited groundwater

lenses on atolls, which will put them out of use and drastically decrease the water supply in this way. These localised threats in Pacific Island Countries must be recognised within the context of international priorities, especially in nations such as Tuvalu where climate change is an all-encompassing threat.

Chapter 3 International and regional efforts in sanitation and water security in the face of climate change

In addition to ongoing scientific research being conducted into the causes and effects of climate change, numerous international efforts have been made to address climate change at the policy development level. Such efforts have been conducted within the context of overarching frameworks such as the Millennium Development Goals (MDGs), the National Adaptation Programme of Action from the UNFCCC, the UN Directive on National Sustainable Development Strategy and the National Action Plans from the Hyogo Framework for Action. There is a strong degree of commonality of principles and objectives between all of these international efforts in climate change-related policy work. Interestingly, it will emerge that the same types of commonalities exist at a smaller scale, specifically across national projects. This will be described in some more detail in Section 6.5.

Climate change adaptation: common principles related to water and sanitation

Globally, several links between climate change and water and sanitation have been identified in the past. The UNFCCC identifies the importance of Climate Change, and climate change adaptation, for sustainable development at the global level. This is demonstrated in its annual Conferences of the Parties, where broad topics concerning international climate change policy are discussed. The United Nations (UN-Water 2007) suggests that 88 per cent of diarrhoeal disease globally is caused by unsafe water and Hutton and Haller (2004) claim that improved water supply reduces diarrhoea morbidity by between 6 to 25 per cent. In the Pacific more specifically, Singh et al. (2010) have observed the link between rising global temperatures and diarrhoeal diseases. The link between these illnesses, unsafe water and rising global temperatures represents some aspects of the role of climate change in causing costs to developing countries. For these reasons, among others, PIFACC has underlined the importance of adapting to climate change in the Pacific region. Furthermore, at the national scale, such as in the atoll nation of Tuvalu, both national policy priorities such as the National Adaptation Programme of Action (NAPA) and the National Sustainable Development Strategy (NSDS), as well as technical studies such as this one, are being used to work towards finding solutions to the problems, resulting from these global links between water quality and climate change. Water security, for example, is an underlying thread in both the NAPA and the NSDS. Health on the other hand, including water-related health, is an overlapping thread in both MDG discussions, as well as the NSDS. As will be mentioned throughout this study, each of the projects being assessed here work on resolving some of the problems listed at the global level, as well as resolving some of the more regionally relevant issues (for example through a targeted Regional Framework for Action with regards to disaster risk management) and country-specific issues (such as with the King Tides in Tuvalu.) Overall, it is difficult to determine the successfulness of these projects in resolving these problems because of a lack of data and because of the degree of commonality involved in the overlaps between the projects – these issues will be discussed in Section 5.

In terms of water security, the global role and importance of water was underlined by the United Nations (UN-Water 2007) who observed water as the pivotal medium through which

climate change affects the earth's ecosystems, human livelihoods and the well-being of societies. The United Nations announced in 2010 that adequate proximate access to clean water is a basic human right. Improved management of water and sanitation is therefore, a point of focus for sustainable development and adaptation to climate change and is closely linked to this because of its impact on all aspects of society, environment and economy. PIFACC (Pacific Islands Framework for Action on Climate Change) has been clear to underline the importance of this line of thought for Pacific island countries. As an example, climate change will affect temperatures and drought severity or frequency therefore, affecting water availability, and potentially damaging agricultural productivity (thus, affecting economic growth), as well as human hygiene and livelihoods. This links climate change adaptation goals with disaster risk management and the RFA (Regional Framework for Action).

Significant investments into policy shifts are required to increase the representation of water in national climate change adaptation agendas. According to UN-Water (2007), the main areas of interest are:

- improving long-term resilience through strengthening institutions;
- strengthening governance and improve water management;
- leveraging additional funds through both increased national budgetary allocations and innovative funding mechanisms for adaptation in water management; and
- investing in cost-effective and adaptive water management as well as technology transfer.

In light of these interests, countries are being urged to pursue a 'no regrets' approach in their water management practices, keeping climate change adaptation in mind and recognising that all major decisions for adaptation should take water resources into consideration. Because climate change and the associated adaptation is a complex issue, a multi-sector and local-to-global approach is also recommended (UN-Water 2007). The extent to which these issues are successfully targeted by individual water projects in Tuvalu will be discussed in Section 6.5.

UN-Water (2007) recommends the inclusion of the following steps for integrating water management and climate change adaptation:

- planning and implementing new investments (e.g. increased rainwater storage);
- adjusting operation, monitoring and regulation practices of existing systems to accommodate new uses or conditions (e.g. population growth and pollution);
- working on maintenance, rehabilitation and re-engineering of existing systems;
- modifying existing processes and demands for existing water systems and users (e.g. water conservation); and
- introducing new efficient technologies (e.g. desalination).

The most challenging issue for the integration of water resource management and climate change adaptation will be institutional change. UN-Water (2007) emphasises the need for institutional change to holistically mainstream water resource management as a core component of climate change adaptation. In these regards, policy and project management and mandates will need to be strengthened, as will the institutions under which they operate, building on the principles of civil society, equality and decentralization.

3.1 UN framework convention on climate change

The United Nations Framework Convention on Climate Change is an international environmental treaty, born out of the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro (also known as the Earth Summit). The negotiations involved Annex 1 countries, Annex 2 countries and developing nations – different interests were promoted by each party, with different outcomes emerging in each of their regards.

The objective of the UNFCCC was to produce a plan of action to stabilise global greenhouse gas emissions in the atmosphere — such as carbon dioxide — so as to reduce the incidence (and ultimately, the effects) of human-induced climate change. This is stated clearly in Article 2 of the convention which is based on the precautionary principle. Currently, the UNFCCC has 194 parties to the convention.

The main outcome of the UNFCCC however, was the Kyoto Protocol, which was set to provide regularly updated, and contextually adjusted emissions targets for different categories of nations around the world. Annual meetings, called 'conferences of the parties' are held to provide a platform for parties to the convention to communicate their successes and updates to the United Nations Secretariat and the IPCC. The UNFCCC itself did not result in mandatory emissions limits. The closest it came was through its benchmarking initiative as part of Article 4, which initially aimed to reduce developed country greenhouse gas emissions to below 1990 levels by the year 2000. Article 4 also emphasised 'common but differentiated responsibilities', including the need for countries to cooperate financially to adapt to the impacts of climate change (specifically, the need for wealthy countries to support poorer countries to achieve emissions targets).

Financing of climate change activities in the Pacific

At the international level, most climate change project financing has come through the Global Environment Facility (GEF) which is an independent financial organisation that provides grants to developing nations and to economies in transition, to design and implement projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. Until recently, this funding was mostly limited to achieving key reporting requirements for the UNFCCC. Increased opportunities for funding emerged following the establishment of the LDC Fund and the Special Climate Change Fund.

All future disbursements of funds under the GEF will be handled under the GEF-Pacific Alliance for Sustainability which, over the next four years, will make available to the region over US$30 million for adaptation and US$14 million for mitigation initiatives.

3.2 National Adaptation Programme of Action for UNFCC

In 2001, the 7th Conference of the Parties (COP) took place to follow up on the UNFCCC, the international environmental treaty that was established almost 10 years earlier. This COP meeting gave rise to the National Adaptation Programme of Action (NAPA). The aim in establishing a NAPA is principally to address the urgent and immediate needs and concerns of developing nations related to the adaptation to the adverse effects of climate change (UNFCCC 2007). In this respect, NAPAs provide a process for countries to identify their priority activities.

Numerous NAPAs have been established to date with examples in the Pacific region, including Tuvalu, Kiribati, Samoa, the Solomon Islands and Kiribati (see UNFCCC 2010 for details). The Tuvalu NAPA is discussed in more detail in section 5.

3.3 PIFACC and regional framework for action

In line with the outcomes of the UNFCCC, Pacific Island Leaders in 2005 adopted the Pacific Islands Framework for Action on Climate Change (PIFACC) 2006 - 2015 (see SPREP 2010 for an introduction). The PIFACC acknowledges that climate change may present a threat to the very existence of certain Pacific island countries and it outlines the broad development priorities for Pacific island countries and territories, at both the regional and the national level. The PIFACC promotes an integrated and multi-stakeholder approach in the sectors of: agriculture; energy; forestry and land use; health; coastal zone management; marine ecosystems; ocean management; tourism and transport (PIFACC 2005).

Following establishment, the Secretariat for the Pacific Regional Environment Programme (SPREP) was directed to develop the Action Plan for implementation. SPREP established a set of national and regional activities to be followed in order to meet key principles of PIFACC. There will be yearly meetings of PIFACC representatives, where specific key themes will be selected for discussion. This will provide yearly opportunities to prioritise areas where little progress has been made and to establish which key principles may have been successfully achieved. These meetings will be essential to contributing to the overall achievement of climate change resilience in the Pacific region (Hay 2010). The objectives of the PIFACC meetings are to:

- update the PICs on regional and international actions undertaken in support of the Framework and Action Plan;
- provide a clear overview of ongoing and planned activities at the national and regional levels with responsible agencies or entities, and agree on mechanisms for measuring progress, identifying difficulties, and addressing actions needing special attention;
- assist donors in understanding climate change initiatives in the region and allow for better targeted assistance to areas in the action plan where there are gaps;
- share lessons learned from best practices in the implementation of climate change programmes;

- engage a wide range of stakeholders and regional organizations;
- provide an opportunity to prepare for international meetings of the UNFCCC; and
- disseminate information on new and existing funding modalities and opportunities.

Other Pacific-wide efforts to mainstream climate change to other sustainable development activities include a mainstreaming exercise initiative by SPREP and other regional agencies aimed at reaching a common understanding of the mainstreaming methodology. A mainstreaming programme has been agreed upon by the key regional agencies, including roles, responsibilities and a preliminary budget with a timeline for the implementation of mainstreaming programmes for 2008 - 2010.

3.4 UN directive on national sustainable development strategies

The concept of the National Sustainable Development Strategies (NSDS) was coined in connection with the implementation stages of the Johannesburg World Summit on Sustainable Development in 2002 where, the full implementation of Agenda 21 was agreed to in the Johannesburg Declaration with associated global sustainability objectives, including the achievement of Millennium Development Goals in a sustainable manner. In the Johannesburg Declaration, there was also substantial mention of multilateral approaches as a pathway forward. The purpose of NSDSs is to integrate social, economic and environmental objectives into a country's national development strategy, taking into account the implications of these factors for differing socio-economic groups and for future generations. The complexity of interactions between these themes requires a clear strategy, whereby countries must have a clear vision of core values and where the nation, as a whole, would like to be in the future. Mechanisms for cross-sectoral policy integration are essential to examine the sustainability of policy decisions taken at different levels and in different sectors. NSDS must provide for the active participation of civil society as well as private sector stakeholders in policy formulation and planning. Finally, inherent to a successful NSDS is the provision for monitoring current social, economic and environmental conditions and likely, future trends to be able to identify realistic objectives and evaluate progress towards specified goals. An NSDS is a living document and must necessarily be changed and updated as time progresses as lessons are learned. An NSDS represents a set of instruments and ways of working to enable sustainable development challenges to be tackled in a coherent and dynamic way (see OECD, undated for further details).

Numerous NSDSs have been created to date with examples in the Pacific region, including Tuvalu, Nauru and the Cook Islands. Increasingly, countries are mainstreaming sustainable development as part of their general national development strategies. The Tuvalu NSSD (National Strategy for Sustainable Development) is discussed in more detail in section 5.

3.5 Millennium Development Goals

In 2000, the Millennium Declaration was adopted by the member states of the United Nations, including all Pacific Island Governments (PIFS 2010). The Millennium Development

Goals were born out of these discussions to capture previously agreed goals in international development in a holistic manner. The eight MDGs that were agreed upon included targets to be achieved by the year 2015 in the areas of: extreme poverty and hunger; universal primary education; promoting gender equality; reducing child mortality; improving maternal health, combating HIV/AIDS and other diseases; ensuring environmental sustainability; and, developing a global partnership for development (PIFS 2010). The global targets that were agreed upon in 2000 have been adjusted over time, following analysis of practical issues in specific countries. More developed UN member countries have, over the years, made repeated commitments to contribute 0.7 per cent of GDP to less developed countries, in support of their achievement of the MDGs, although there has been criticism that the funds being provided by more developed countries come with no specific target for disbursement.

3.6 Hyogo framework for action and disaster risk reduction

The Hyogo Framework for Action was developed at the 2005 World Conference on Disaster Reduction in Japan with the aim of increasing the resilience of nations and communities to disasters.

The Hyogo Framework of Action is intended to support the targeting of both the Disaster Management (DM) and the Disaster Risk Reduction (DRR) components of disaster risk management (DRM) in order to substantially reduce disaster losses. DM is defined as 'the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster (UNISDR). DRR is defined by UNISDR as the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

In support for DM and DRR, the main aims of the Hyogo Framework for Action (HFA) are to:

- ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation;
- identify, assess and monitor disaster risks and enhance early warning;
- use knowledge, innovation and education to build a culture of resilience at all levels;
- reduce the underlying risk factors; and
- strengthen disaster preparedness for effective response at all levels (UNISDR 2005.)

In the Pacific, the HFA formed the basis of the Regional Framework for Action (RFA). It was decided at the 12th Regional Disaster Management Meeting in 2005, that developing and strengthening a coordinated approach on an 'all hazards' basis across the region would significantly improve the capacity of Pacific island countries to reduce their vulnerabilities and better manage disasters when they occur. The ultimate goal is to mainstream DRR and DM policies into all levels of national policies, planning processes and decision making.

These frameworks are designed to build the resilience of nations and communities to disasters.

Given the impact that climate change may have on the frequency or severity of disasters, the development of the HFA is important to support countries to not merely respond to negative events such as floods worsened by climate change, but also to reduce the risk of such disasters by adaptation. According to the UN Secretary General's High level Panel Report on 'Delivering as One' (UN 2006): “With more than 75 per cent of the world's people living in disaster-prone areas, risk reduction has been recognized as a cost-effective strategy to protecting livelihoods and achieving the internationally agreed development goals … presently, there is insufficient 'disaster proofing of the Millennium Development Goals' through mainstreaming risk reduction into development strategies”. With respect to DRM, mainstreaming therefore refers to the intrinsic inclusion of disaster proofing policies in a country’s development strategy and other pertinent policies[1].

In implementing the RFA, Pacific island countries have seen the development of numerous national action plans (NAPs) for disaster risk management. DRM NAPs outline national sectoral level priorities linked to the objectives specified by HFA (UNISDR 2005). Pacific DRM NAPs first began to be developed in 2005 with the NAP for Vanuatu. Numerous other countries have followed suit including Tuvalu, RMI and Cook Islands.

Climate change and drought

According to the most recent Global Assessment Report for Disaster Risk Reduction (2011), drought risks are particularly important due to the uncertainties surrounding their severity, frequency and regularity. The global effects of droughts are no doubt severe, often causing widespread suffering and economic damages/losses. Nevertheless, and even at the international scale, comprehensive assessments of the risks imposed by droughts are only just beginning (GAR 2011). Strengthening drought risk management is an integral part to risk governance and will be fundamental to maintaining and improving quality of life in many countries into the future. Drought risk remains poorly understood and increased efforts in the assimilation of drought meteorological data and associated drought-related economic losses will be crucial (GAR 2011; UN 2011). Drought risks at the national level, and especially in Small Island States (SIS) such as Tuvalu, pose very specific water scarcity and water quality problems which must be targeted within the context of climate change. This creates complementarities between water and climate change project and planning work.

[1] A good example of disaster risk reduction mainstreaming is in Fiji, where six primary and secondary schools in the urban vicinity of Suva decided to reduce their vulnerability to earthquakes in accordance with principles outlined by the National Disaster Management Board. A contractor was selected to carry out changes, such as building works to ensure that the National Building Code of Fiji was being adequately adhered to (UNCRD, 2009).

3.7 Linking disaster risk management and climate change

While the establishment of efforts to address climate change and disaster risk are important, early efforts to use these approaches to optimise efforts in adaptation were likely damaged by the fact that the climate change adaptation and DRM sectors were treated as separate and distinct (GFDRR 2006). GFDRR (2006) refers to an indelible link between disaster risk reduction and climate change adaptation, as underlined in 2007 by the Bali Plan of Action. In line with this, the World Bank has produced guiding principles under the *Strategic Framework for Development and Climate Change* to support and promote synergies in developing countries between disaster risk reduction and climate change adaptation. Since its establishment in 2006, and in line with new developments in the international arena, the GFDRR continues to target the mainstreaming disaster risk reduction and climate change adaptation into developing countries' development strategies, so as to reduce long run vulnerabilities.

GFDRR's approach to achieving this involves:

- evidence-based policy and strategy formulation;
- provision of services to developing nations, including capacity building support to foster ownership;
- results-based monitoring and evaluation, focusing on country development strategies; and
- emphasis on a cross-sectoral approach in its climate change adaptation recommendations.

In the Pacific, this link between DRM and CC is increasingly addressed with recommendations from a number of fora, including the meetings of the Pacific Partnership for Disaster Risk Management in 2010, the Pacific Climate change Roundtable in 2010, the Pacific Disaster Risk Management Platform of 2011 and meetings of the Forum leaders. A 'road map' to guide the integration of DRM and CC actions and priorities in the Pacific is presently being developed. In the interim, significant moves towards integration have been made with the establishment of a joint NAP that combined DRM and CC issues (effectively a joint NAPA/DRM NAOP) being released in 2010 for Tonga. Following the development of the regional's first joint NAP – or JNAP as they are termed – in this way, other nations are now following suit to establish JNAPs, such as PNG. Following on with the regional so-called JNAP, Tuvalu has taken a step ahead in developing a National Strategic Action Plan (NSAP), integrating both CC and DRM issues. Although this could be seen as a positive and productive step towards achieving real outcomes in mainstreaming the issues of climate change and DRM, many countries' discussions are limited to discussions of the solutions with very few having yet realised any activity plans.

3.8 Regional climate change adaptation activities

In light of the concerns that the Pacific community faces in water security and the increasing threat that climate change compounds in water security, various initiatives have been established to assist the region in assessing and documenting vulnerabilities and potential

solutions that would be acceptable to local communities. The Pacific region has begun implementation of a regional adaptation project that will introduce adaptation options in the areas of water resources management, food security, coastal zone management and infrastructure. This regional project is the Pacific Adaptation to Climate Change Project (PACC) and is operational across 14 Pacific island countries, and is funded by the Special Climate Change Fund from the GEF. The objective of the PACC is to enhance the resilience of a number of key development sectors (including water resources management) to adverse effects of climate change. To achieve this objective, the PACC will focus on long-term planning of adaptation response measures, strategies and policies. Regional and national adaptation financing instruments will also be developed to ensure the long-term sustainability of the project.

Pacific regional action plan on sustainable water management

In 2002, regional consultations were held across the Pacific to consider a strategic plan to address water issues. The outcome of these deliberations was the Pacific Regional Action Plan on Sustainable Water Management, funded by the ADB and SOPAC/SPC and ultimately, endorsed by 18 island countries. The Regional Action Plan was aimed at creating concrete commitment on water and sanitation issues at the regional level and to strengthen national policies and institutional arrangements through enhancing public awareness and developing a shared understanding. The Regional Action Plan report was structured around six themes of discussion: water resources management, islands vulnerability, awareness, technology, institutional arrangements and finance.

In 2003, the World Water Forum was held in Japan and the water issues of small island states were formally acknowledged by the global community. Furthermore, at this summit various recommitments by Pacific island countries were made in line with international sustainable development standards and treaties (such as Agenda 21 and the Barbados Programme of Action.

In 2007, the Asia-Pacific Water Summit in Japan made many of the same recommendations as listed above, additionally recommending that regional platforms be created for the sharing of scientific information, knowledge coordination, collective monitoring, and the establishment of a network of financing organisations and institutions in coordination with existing programmes.

National water and sanitation plans

The EU-funded Pacific IWRM national planning programme, implemented by SOPAC/SPC, is in negotiations with Tuvalu at the moment with the aims of delineating a Water and Sanitation Plan. A core component of this is the Water and Sanitation committee, which is a cross-institutional group in Tuvalu that includes various representatives from the government, NGOs and island community representatives. It must be noted that, although the concept of IWRM aims to influence national approaches to water management policy, the GEF-IWRM work, on the other hand, involves very specific project work. However, the EU-IWRM work ultimately reinforces the GEF-IWRM work.

The Pacific IWRM national planning programme was born out of the 10-year Water Master Plan and years of work in Tuvalu on the IWP. Initially, from 2002 - 2005, the Pacific IWRM programme conducted extensive community and government consultation, working towards building a draft plan to reduce problems and pressure on limited water resources in Tuvalu. A draft water and sanitation plan has been produced and reviewed and the principal objectives of the Tuvalu water and sanitation plan are to:

- provide sufficient good quality freshwater to Tuvaluans; and
- protect all water resources to enhance the health of the environment and its people.

The main issues to be overcome include inadequate quantity of rainwater collected and the salinity of groundwater. The lack of household-level expertise with which to deal with testing of water supplied from rainwater tanks is a compounding issue. The action plan underlined includes, providing more water tanks to increase water storage capacity, introducing appropriate water policies and legislations and a campaign on water quality testing and water boiling. Difficulties have already been identified, concerning lack of interest from local communities and insufficient local expertise, as well as overlaps of this draft policy plan with outputs of ongoing projects, such as the EU B-Envelope and the GEF IWRM.

3.9 Mainstreaming

Considering the common principles of climate change adaptation at the global scale noted at the beginning of Section 3, it must be emphasised that significant mainstreaming consultation and planning has taken place across the Pacific in line with the principles of sustainable development. For example, climate change adaptation priorities have frequently been identified as part of the development of national action plans (either for climate change adaptation only, or as part of joint national action plans with disaster risk management as well). These priorities have in some cases (e.g. Tonga) been budgeted. However, relatively little action has been taken to realise any planned activities. Actual implementation of activities will be an essential component of climate change adaptation in the coming years, if water scarcity is to be successfully resolved in the long run.

Limited implementation of work against climate change priorities may reflect confused priorities/overlaps between projects at the national level (for example, where global and local prerequisites for climate change adaptation are concerned and duplication of project objectives occurs). Overlaps between projects at the national level can make it difficult for different projects to accurately target the exact problems that it has identified in a strictly measurable fashion. However, ensuring that these overlaps are dealt with to maximise the use of scarce funding, resources and capacity-building opportunities, it will be essential to increase collaboration across projects and across entities involved.

Chapter 4 Water security and climate change challenges in Tuvalu

4.1 Key development challenges

Tuvalu is a Pacific island country of nine low-lying coral atolls (Image 1), with a humid tropical climate and high rainfall, limited land area and high mean population densities. The main island of Tuvalu is Funafuti, containing the country's capital and 47 per cent of the population of Tuvalu (Paeniu 2010) (around 639 households or 4492 people (Government of Tuvalu 2002).

Image 1 Map of Tuvalu

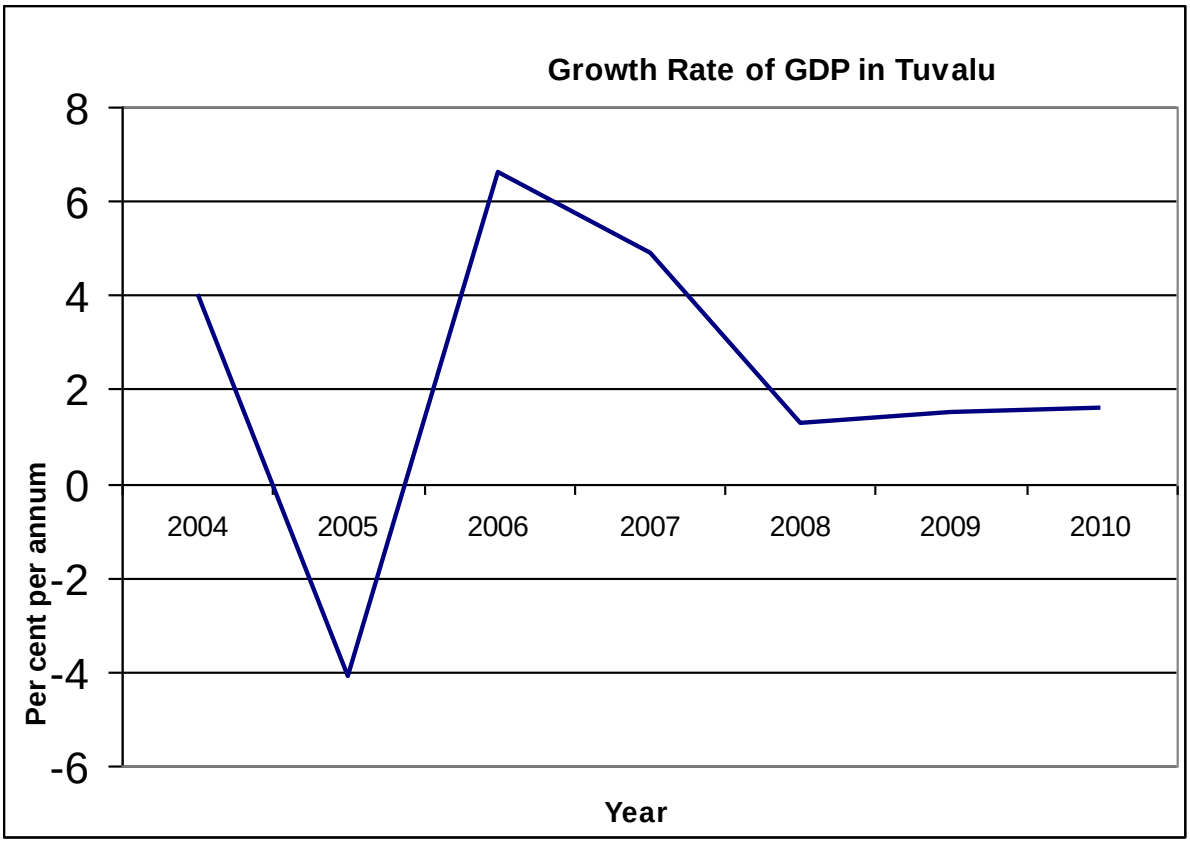
Source: Government of Tuvalu (2005)

Tuvalu is presently a least developed country because it has a Human Poverty Indicator of 9.2, a reduction from 7.3 in 1998, indicating an increase in national poverty which can render communities more vulnerable to extreme events[2]. The increase in poverty may be linked to falls in GPD in recent years (Figure 2).

[2] UNDPPC (date unknown) http://www.undppc.org.fj/_resources/article/files/5.pdf

At the same time, human development in Tuvalu has nevertheless improved in some respects with its Human Development Indicator at 0.7, up from its assessment of 0.58 in 1998 (Government of Tuvalu 2002).

Figure 2 GDP in Tuvalu



Source: Pacific Islands Forum Secretariat (2010)

Evidence on progress against MDGs indicates that progress has been made towards to sustainable resource use in Tuvalu (Table 2).

Table 2 Meeting MDGs in Tuvalu

Indicator		Tuvalu Baseline (% 1991)	Most Recent Status (% 2002)	MDG Target (% 2015)
Proportion of households with sustainable access to an improved water source (urban and rural)	National	90	97	95
	Funafuti (urban)	93	98	97
	Outer islands (rural)	98	97	99
Proportion of households with sustainable access to improved sanitation (urban and rural)	National	77	84	89
	Funafuti (urban)	84	88	92
	Outer islands (rural)	74	81	87

Source: Lal et al. (2006), PIFS (2010) and WHO/UNICEF (2010)

Nevertheless, Lal et al. (2006) argues that the degree of human development progress indicated by such data may be misleading, observing that – in the case of water and sanitation – figures on access to water and sanitation in Tuvalu describe access to facilities only, but many facilities are actually of poor quality as a result of unenforced building codes and poorly constructed septic tanks, which can also have its own impact on sanitation and hygiene (PIFS 2010). While the figures indicate high levels of access to improved drinking water services, it is in fact not uncommon for Tuvalu to suffer droughts where the access is not achieved for months at a time – as was the case for the 2011 state of emergency (drought).

A complicating issue for ensuring human development in Tuvalu is the emergence in recent years of urban drift as large numbers of people move from outer islands to the capital in search of access of jobs and amenities. This puts pressure on the population of Funafuti in the face of scarce resources such as water. Population growth in Funafuti over the last decade has been 17 per cent, compared to *negative* growth of 2.6 per cent in the outer islands. The population density on the country's main atoll of Funafuti is now 1610 person/km^2 compared to 373 persons/km^2 for Tuvalu overall (Government of Tuvalu 2002). This has implications, in terms of impacts during natural hazards, especially in terms of health costs and poor access to clean water.

4.2 Climactic hazards facing Tuvalu

Hydro-meteorological hazards facing Tuvalu include tropical cyclones, king tides, storm surges, El Niño/La Niña phenomena and droughts. Tuvalu lies in a region that is susceptible to cyclonic activity. Cyclonic activity and associated high winds cause storm surges and consequent inundation of the low-lying atoll of Funafuti (SOPAC 2011). There have been seven major cyclones in the past 40 years (Table 3).

Table 3 Cyclones in Tuvalu

Year	Date	Tropical Cyclone	Wind speed (knots)
1972	21 November	Bebe	70-100
1990	30 January	Ofa	64
1993	1 January	Nina	55
1997	5 March	Gavin	75
1997	12 March	Hina	50
1997	10 July	Keli	90
2003	12 January	Ami	55

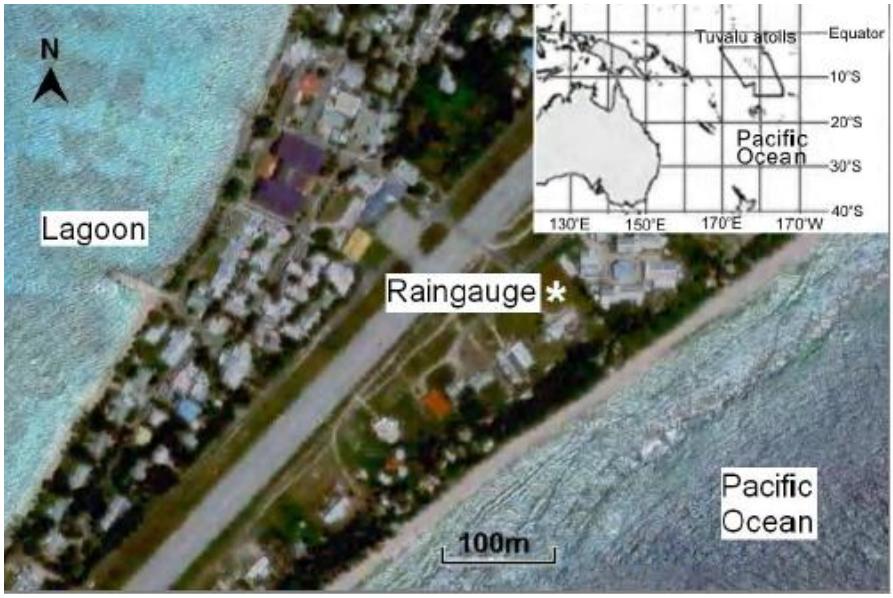
Source: Office of the Prime Minister of Tuvalu, taken from SOPAC (2011)

At the same time, being low lying in nature, Funafuti is susceptible to severe storm surges and king tides, both of which can flood the island, causing primary land loss and water resource degradation. With the estimated sea level rise occurring due to climate change, Tuvalu might lose up to one metre of coastline area per year (Bardsley and Vavae 2009) – a significant loss for Funafuti where the widest part is just a few metres (Image 2). This phenomenon may also worsen the quality of groundwater, with the associated sanitation threats, such as septic tanks overflowing into and contaminating adjacent areas.

Furthermore, contamination of rainwater tanks (especially underground rainwater cisterns) may occur in the same way, especially if threatened by saline intrusion during storm surges and King Tides. The major threat of population growth worsens this effect, due to an increase in septic tanks polluting the ground (Lal et al. 2006).

King Tides are now an annual event in Funafuti and, with rising sea levels due to climate change, could become more severe. According to IPCC (2007), the projected increase in sea level in the 21st century is between 0.5 and 0.95 metres. The highest point on Funafuti is at 4.5m and small increases in sea level can have large effects on the intensity and impact of king tides, as well as tides, storm surges and cyclones more generally.

Image 2 Width of Funafuti



Source: Bardsley and Vavae (2009)

Concerns about storm surges and king tides in Tuvalu are reflected in the Tuvalu National Adaptation Programme of Action (Government of Tuvalu 2007a) which notes that Tuvalu frequently suffers storm surges during cyclonic disturbances. The NAPA suggests that maximum wave heights will continue to increase (Government of Tuvalu 2007a) and might therefore, result in severe storm surges, causing increased damage.

An important part of climate change adaptation will be improving such buffer stocks of water. According to IPCC (2007), worsening droughts will cause further disruption and damage to potable water sources in water-stressed environments.

In addition to coastal flooding, Tuvalu is threatened with regular droughts. The regularity with which drought periods occur in Tuvalu reflect the alternating influences of the Inter-tropical Convergence Zone and the South Pacific Convergence Zone, which give rise to annual precipitation variation with a dry season from April to November and a wet season from December to March (Bardsley and Vavae 2009).

Finally, the effects, or rather the costs of disasters, are likely to increase over time, especially with the increasing population of Funafuti (Image 3). This suggests that increasing numbers of people will be affected by living closer to the water where they are more vulnerable to

storm surges. Storm surges are likely to increase with higher prominence of natural disasters such as cyclones, which are suggested in the literature to increase in line with worsening climate change.

4.3 Climate change-related hazards

Tuvalu has become something of a "poster child" for climate change discussion for many academics, scientists, politicians and commentators. According to Bindoff et al. (2007), sea level has been rising since the beginning of the 1800s at a rate of 1.7 ± 0.5 mm per year, although this increase has not happened at a constant rate (Xue 2005). Xue (2005) observes that there is no satellite evidence of sea level rise in Tuvalu, with the only evidence of sea level rise existing during storm surges and king tides. As a result, the specific frequency and magnitude of sea level rise for Tuvalu cannot be predicted accurately.

Image 3 Fongafale Population Density (1941-2003)

Source: Webb (2006).

The impact of sea level rise of Tuvalu is thus yet to be fully understood with some commentators focusing on the relocation of Tuvaluan citizens for adaptation (Germanwatch 2004) while others question sea level rise as a key driver for current migration at all (Mortreux and Barnett 2008).

While life on Tuvalu in the face of climate change may not require relocation, the daily lives of Tuvaluans may, nevertheless, be affected by increased flooding from changes in sea level and their impact on storm surges, as well as impacts on water security. Coastal flooding of atolls can result in salinisation of ground water resources. At the same time, increased variation in precipitation and temperature can result in more or less frequent rains and the lack of potable water resources. Oxfam (2011) observes that the scarce rainwater forces communities across Tuvalu to resort to the limited groundwater resources. Unfortunately, this is not a sustainable option in Funafuti as a result of significant saltwater intrusion as a result of over-extraction and excavation of the borrow pits, as well as (but less importantly) sudden-onset king tides and storm surges. Damage to groundwater resources is compounded by manmade pollution, stemming principally from ineffective and over-used dumping sites and sewerage systems (Lal et al. 2006).

In order to adapt to climate change, Hay and Mimuro (2006) thus suggest that current climate variability/extremes, and anticipated longer-term changes in climate in the Asia-Pacific region – for example, flooding, heat waves, salt water intrusion, wind damage and drought – represent major impediments to enhancing, and achieving sustainability. Historically, countries in the Asia-Pacific region have adapted to environmental change, mainly in a reactive manner. However, there is currently an increasing emphasis on proactive rather than reactive climate change adaptation, which will require higher calibre climate change scientific data for decision-making. It is recommended that Pacific island countries take advantage of this to improve their data collection abilities, for long-term sustainable development (Hays and Mimuro 2006).

Chapter5 Water sector in Tuvalu

The islands of Tuvalu are generally composed of very coarse coral gravel and sands which cannot sustain substantial fresh groundwater lenses (Webb 2007). Instead, the primary source of freshwater is from stored household and communal rainwater, although other sources of water may complement this. There is no central water system in Tuvalu except for a few government reserves that are under the control of the government which are used to supply people when the need arises at $13.50 per 500 gallons, coupled with desalinated water.

5.1 Sources of water in Tuvalu

Rainwater access

The porous nature of Funafuti Atoll means that surface water is negligible (Webb 2007). Therefore, the main source of water supply in Tuvalu is from rainwater harvesting via rainwater tanks, attached to private household roofing systems. According to Table 4 from Baarsch and Nguyen Berg (2011), there are several necessary conditions for access to safe drinking water, for the population of Funafuti. The most important requirements are for sufficiently large roof and tanks, sealed gutters, and effective household water treatment for consumption.

In the event of droughts, the government provides a rationed supply of water from the government water cisterns and when a state of emergency is staged, government controls the management of all available water on the island to provide just enough rations for the people. This is discussed in further detail later.

Table 4 Conditions for safe access to drinking water in Funafuti

Systems	Elements of System	Recommended conditions
Catchment System	Roof	Inclined At least 2m^3 per person living in household Made with corrugated iron No holes Fully and solidly nailed using good roofing nails
	Gutters	Not leaking Covering entire length of the roof on both sides (unless the roof only slopes in one direction Covering all available roofing space (including small sheds) Closed on both sides Inclined at the correct angle Incorporated screens for larger waste and small animals
	Pipes	Inclined from the gutter to the top of the water tank
Storage System	Screens	Mesh screen on top of the tank, at the point where the pipe pours water into the tank Cleaned weekly to remove dead animals/animal faecal matter/leaves

	Tanks	At least 5m^3 of storage capacity available per person living in the household
Consumption	Treatment	Filter water but only if this has been proved effective Electric boiler if there is sufficient quantity of water, and large enough boiler, to be energy efficient Gas (or fuel) boiler First flush device installed

Source: Adapted from Baarsch and Nguyen Berg (2011)

Another source of rainwater is communal water cisterns provided by the Government of Tuvalu. On the main Tuvalu atoll of Funafuti, these are located near public buildings such as offices, Falekaupule or Ahiga, churches, schools and hospitals. Usage is subject to control, particularly during periods of low rainfall or drought, and consequent water shortage.

According to IWRM (2007), several threats exist to rainwater quality on Tuvalu at present, including:

- irregularly cleaned guttering (leaves decaying and dead animals contaminate the water); and
- insufficient care in boiling rainwater for drinking (IWRM 2007).

They (IWRM 2007) also observe that insufficient roof catchment area, insufficient rain water tank, combined with prolonged drought (low rainfall) and high temperatures can hinder the effectiveness of rainwater harvesting as a solution to water supplies (IWRM 2007).

Groundwater access

According to the GEF IWRM Diagnostic Report (2007), groundwater is available on all atolls of Tuvalu. However, the extent and quality is not uniform as it depends on the size of the island and the soil's permeability. In Tuvalu the total estimated groundwater area is at 4.9km^2. It should also be noted that the majority of islands have wells. Importantly however, there are no recently recorded freshwater resources on Funafuti.

According to Webb (2007), samples of groundwater throughout the islands of Tuvalu had acceptable average groundwater salinity, at low enough levels for successful taro cultivation, except Funafuti.

On the other hand, over-extraction around Tuvalu in 1999 and 2000 resulted in groundwater becoming brackish and salty due to the water level dropping with serious consequences for the vegetation as witnessed in Vaitupu in particular, but also on Fongafale (Webb 2007). On many of the islands of Tuvalu, groundwater is available beneath villages, which is why the villages were originally settled in that location. However, because of the extensive use of pit latrines and septic tanks, the water is contaminated and its use can lead to disease. For example, use of flush toilets can lead to septic tank effluent and potentially contaminate scarce groundwater resources (Baarsch and Nguyen Berg 2011). For more information on sanitation issues, see Box 1.

Box 1 Sanitation issues

The quality of the existing groundwater is variable such that the groundwater has historically been regarded as a non-potable and non-secure secondary source of water (Webb 2007). According to Webb (2007), the use of Funafuti groundwater as a secondary source of water has been severely compromised by saline intrusion as well as (but less importantly) pollution from inadequate sanitation systems on the island. Waterborne diseases are now common and exact a significant toll on the health, wellbeing and productivity of the population. The coastal areas of Funafuti are a major source of livelihood and also contain marine biodiversity of conservation value. These areas are also under threat from poor solid and liquid waste management.

The largest threat to sanitation, with regards to personal hygiene and contaminated rainwater cisterns, occurs during king tides which normally take place in February or March. More specifically, threats take place in the location of the Borrow Pits at the Lofeagai district, in the northernmost area of the Fongafale islet. The Borrow Pits represent large holes excavated by the Americans during World War II to provide material with which to build the air strip and have since been filled with water and rubbish. The threats to sanitation can be intensified during these periods where higher tides cause salt intrusion and faecal contamination through the flooding of septic tanks and other leaching. Additionally, the exposure of these waters to humans may be intensified during dry season or drought periods, where rainwater is lacking and families might instead use the Borrow Pit water for bathing in and cooking. These communities can be disproportionately affected by poor health and low drought-period water security.

The GEF IWRM Diagnostic Report (IWRM 2007) confirmed that the Borrow Pit area had a high propensity of contamination from several sources:

pig faecal matter;

human faecal matter from leaking septic tanks and open defecation;

rotting biological matter and associated eutrophication;

heavy metals from solid waste; and,

saline intrusion.

Consequently, it is presumed that this water was not completely safe for human consumption or for household use.

Baarsch and Nguyen Berg (2011) claim that exposure to these waters is damaging to health, potentially causing effects such as skin lesions, neurological effects, obstetric problems, high blood pressure, diabetes mellitus, respiratory diseases, cardiovascular diseases and skin/lung/bladder cancer. Experts from the Health sector in Tuvalu (Dr. Ituaso-Conway, Princess Margaret Hospital Tuvalu, personal communication 2011) also confirmed that exposure to the polluted water had negative health effects but observed that detailed data on the increase in water-related diseases arising from polluted water was not available.

The lack of any potable groundwater resources suggests that the community is reliant on rainwater harvesting (Webb 2007). This reliance renders the community is vulnerable to variations in climate such that any reductions in rainfall or extreme rainfall events may compromise access to freshwater. Other hazards, such as larger king tides and storm surges, may compound the effect of these climatic variations by disrupting daily life, causing sanitation problems and destroying crops, for example.

In addition to hazards like storm surges and king tides, seawater is increasingly seeping through the ground, salting the arable soil and ground water. Growing the traditional pulaka, taro, papaya, breadfruits and bananas becomes harder because of worsening salinisation. Consequently, and in combination with population growth, people are increasingly dependent on costly imported food[3]. Water and food security are therefore, threatened by the sea level rise that results from climate change.

Desalination

Concerns over the drought vulnerability of this high-density population have resulted in an increase of dry season water demand for desalinated water. The lack of sustainability of operating this desalination plant was frequently highlighted by Government of Tuvalu representatives during the May 2011 SOPAC/SPC mission. Issues of concern included:

- high electricity costs;
- high maintenance costs; and
- drain therefore, on limited government resources.

Originally for emergency use only, desalination is now used as a buffer to the main rainwater supply on Funafuti. The operating plant was donated in 2006 by the government of Japan, in addition to an older Japanese plant from 1999 which is not functioning but is kept for the use of spare parts. The functioning plant produces about 50m³ per day on Funafuti and operates for ¾ of the year. The plant on Funafuti produces water at a unit cost of around AU$17 per m^3 (Dave Duncan, Engineer, GEF IWRM project, personal communication November 2011). On Funafuti, seawater is extracted from the lagoon and the source quality is dubious due to its closeness to the village (IWRM 2007). It is recommended in the Integrated Water Resources Management Plan that cheaper ways need to be identified to meet public demand with minimal dependence on desalinated water.

Bottled water

Limited amounts of bottled water, usually imported from Fiji, are brought in to Tuvalu. The average price per litre of bottled water in Tuvalu is AU$0.7.

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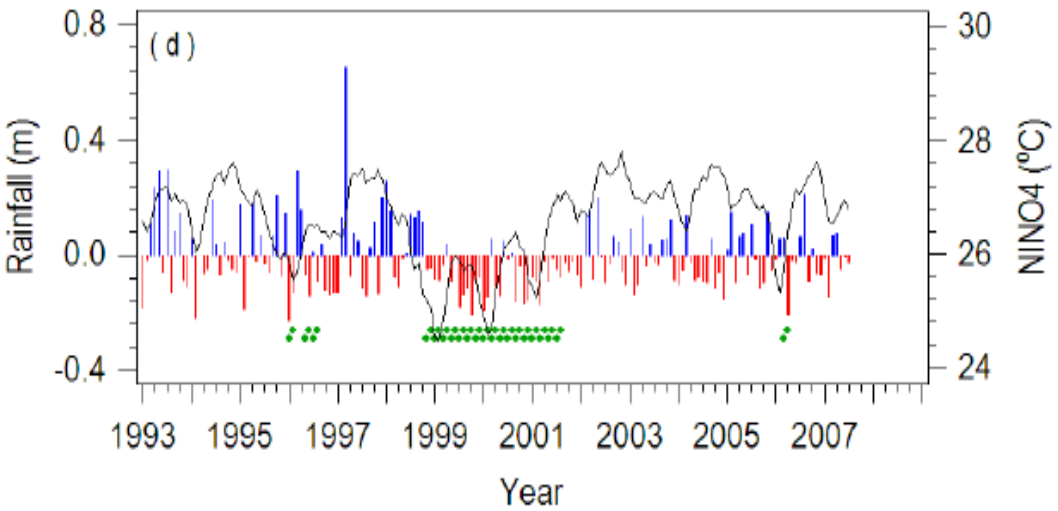
[3] http://uniteforclimate.org/2011/02/king-tides-on-funafuti-via-klima-tuvalu-no/

5.2 Water security issues

Rainfall and rainwater harvesting has been the primary source of water supply in Tuvalu since the early 1980s when most families took advantage of an aid project to provide steel-cement storage tanks attached to small areas of roofing sheets (Baarsch and Nguyen Berg 2011). The catchment provided in the 1980s by AusAID project had an approximate capacity of 3.6 m³ and was intended only to meet drinking water demands. However, once the usage of the people supplied increased, the available water quickly depleted, leading to increased needs to find other means to adapt to climate change and potentially changing weather patterns (Pacific Water 2011). Current polyethylene rainwater harvesting systems, like those provided under the EU B-Envelope project, can hold 10,000 litres of rainwater.

In addition to existing limits on the water available, Tuvalu experiences extended droughts which, given that rain is the main source of fresh water to the local population (Bardsley and Vavae 2009), can create impediments to development. Bardsley and Vavae (2009) note the inextricable link in Tuvalu between rainfall and temperatures (Figure 3), noting that rainwater supply is under increased strain during dry periods which happens annually for around 3 months between of April and November. These dry periods may or may not develop into droughts, but have done so regularly in the past few years. The Meteorological Office in Tuvalu has begun to conduct some measurements of sea surface temperatures in order to be able to better predict droughts.

Figure 3 Monthly (1945-2007) sea surface temperature and Funafuti rainfall deviations from monthly means



Source: Bardsley and Vavae (2009)

The average dry period is about 3 months, and droughts can last for the entire duration of this dry period. During dry and especially drought periods, many households are unable to meet their water needs, even with the presence of rainwater tanks (Baarsch and Nguyen Berg 2011). Households deal with this water scarcity in several ways:

- ask to use neighbours' rainwater supply;

- purchase desalinated water from the Public Works Department;
- obtain water from the nearest government or Kaupule public water cistern, using buckets carried on foot or on scooters. During the drought season, water from the four Kaupule cisterns is free. When it is raining, people have to pay 5 cents per litre. During droughts, water is rationed at six buckets in the morning and six in the evening at the onset of a drought. After one month of drought, this is reduced to four buckets in the evening and four in the morning. This can be reduced further during prolonged droughts, such as was experienced in 2010; after around a month or six weeks of drought, water ration was reduced to two buckets in the morning and two in the evening, during September and December of 2010; and
- obtain bottled water at an average price of AU$0.7 per litre.

As a result, drought periods negatively impact household wealth.

5.3 Water and sanitation status and growing challenges on Funafuti

Given that Tuvalu's islands are small coral atolls, the water tables are usually located within 1 – 1.3 metres (m) of the surface. A key pressure on the water tables are pollutants from leaking septic tanks and rubbish tips that can easily move into the groundwater and from the groundwater lens into coastal lagoons (Lal et al. 2006).

Adding to this pollution problem is a lack of coordination and harmonisation of "management" of water and sanitation between national government agencies (Uluao Lauti, Kaupule Town Council, Funafuti, personal communication, 2011), the local government (the *Kaupule*) and donor efforts (Uluao Lauti, Kaupule Town Council, Funafuti, personal communication, 2011).

Additionally, in Funafuti, there is the constant and increasing threat of a growing population on this limited land space. This results in an overflow in terms of sanitation and water waste. Many human health and sanitation issues on Funafuti are caused by the pollution of groundwater and coastal lagoons (Baarsch and Nguyen Berg 2011). These effects cause human suffering, as well as a significant economic cost. These costs, including the cost of medicine and health services, are borne by the national government. There are also costs associated with the preventative measures taken by households, including the cost of collecting water from the town council catchment, purchasing bottled water, and desalinated water. Such costs will continue to increase in the future unless improved water and sanitation management efforts are maintained (Lal et al. 2006).

5.4 Addressing water and sanitation challenges in Tuvalu

Given global and regional developments in climate change adaptation and disaster risk management, numerous institutional frameworks have emerged in Tuvalu within which water security is being targeted. Following the establishment of the NSDS process under the UN Directive of 2002, Tuvalu completed its own National Sustainable Development Plan or *Te Kakeega* in 2005.

Te Kakeega, which in Tuvaluan means 'the act of scaling or climbing upwards' as well as 'progressive development', outlines a 10-year plan that focuses on eight strategic areas:

- good governance
- macroeconomic growth and stability
- social development, health, welfare, youth, gender, housing and poverty alleviation
- outer island and Falekaupule development
- employment and private sector development
- human resource development
- natural resources
- infrastructure and support services

Under this final strategic area, climate change adaptation is mentioned, specifically as an aim to 'minimise climate change impacts' and therefore, climate change adaptation. In relation to water, the Te Kakeega recognises water as a priority in relation to its themes on Natural Resources, as well as Infrastructure and Support Services. It recommends improved water quantity (provision and conservation) as well as improved water quality (including through, for example, improved waste management). The Te Kakeega aims to support water priorities as part of the wider targets of the Millennium Development Goals. For example, improvements in water quality and water security will be crucial to achieving national MDG objectives in the areas of reducing poverty, improving health and improving overall household living standards in Funafuti. Specifically, the Te Kakeega describes the need for significant awareness raising in the area of water resource management. The Te Kakeega is supported by numerous international donors such as ADB and SPC.

In addition to the NSDS, and pursuant to the UNFCC (noted in Section 3.1), Tuvalu has developed and commenced implementation of a National Adaptation Programme of Action (NAPA) to manage and support activities to adapt to climate change. In recent years, Tuvalu has conducted a number of activities to improve economic development and reduce vulnerabilities to disasters, including climate change-related events.

The NAPA for Tuvalu has seven main objectives, much of which focuses on the outer islands, although some also apply to the main island of Funafuti:

Table 5 Tuvalu NAPA main objectives

1	Disaster risk reduction	To increase the protection of coastal areas from erosion and to increase the protection of coastal communities from natural phenomena. These objectives will certainly require significant climate change adaptation strategies such as increasing man-made coastal defences and planting a green belt along coastlines to protect against cyclonic activity
2	Agriculture	Increasing subsistence pit-grown pulaka productivity through introduction of a salt tolerant pulaka species
3	Water security	Adaptation to frequent water shortages through increasing household

		water capacity, water collection accessories, and water conservation techniques
4	Water quality	Strengthening Community health through control of vector borne/climate sensitive diseases and promotion access to quality potable water
5	Conservation	Strengthening of community-based conservation programmes on highly vulnerable near-shore marine ecosystems
6	Disaster preparedness	strengthening community disaster preparedness and response potential
7	Coral reefs/fisheries	adaptation to near-shore coastal shellfish fisheries resources and coral reef ecosystem productivity

Objectives three and four of the NAPA are particularly relevant to water security. In this context, numerous projects have been established in Tuvalu to support the implementation of these goals (sections 5 and 6).

Following the endorsement of the RFA on disaster risk management, Tuvalu, in 2005, developed its stakeholder-based disaster risk management NAP, which was endorsed by the Tuvalu Cabinet in 2006 to mainstream disaster risk and climate change risk considerations.

In 2007, the Government of Tuvalu reviewed the National Disaster Management Act and reaffirmed its commitment to address DRM. However, although this commitment represents a milestone in the development of DRM in Tuvalu, there is significant room for improvement in terms of enhancing community preparedness to natural disasters (SOPAC 2011). The NAP itself is still in the draft stages and meetings on the matter have just been held between SOPAC/SPC and the government and Tuvalu. The 2011 Disaster Risk Management Implementation plan was drafted following a scoping mission by the SPC Applied Science and Technology division, and agreed support from the Government of Tuvalu among other stakeholders. The plan takes integral consideration of climate change adaptation and the importance of community-level disaster risk management good practise, improvements in which are included as an expected outcome of Tuvalu's draft national action plan for DRM, as of 2011.

5.5 Externally supported projects

According to Lal et al. (2006), the Government of Tuvalu was contributing around AU$132,468 to water developments every year (at 2006 prices) as part of their regular sector budget allocation. These funds are primarily used to pay staff to take care of water treatment and supply, for example, driving the water tank trucks to supply water to communities during emergencies. Nevertheless, donor agencies fund most of the water-related work on Tuvalu. Key projects presently underway in Tuvalu that address water security are summarised in Table 6. The intended benefits of many of these projects complement each other.

Table 6 Other water-related projects in Tuvalu

Project	Expected/achieved outcomes	International entity responsible
COMPLETED PROJECTS		

AusAID	Installing 300 rainwater tanks in Funafuti in 2009, funded by AusAID and executed by the University of the South Pacific	AusAID
Pacific IWRM National Planning Programme	Supporting mainstream IWRM and water use efficiency practices in national planning processes. Other objectives are to: balance conflicting uses of scarce freshwater resources; improve public and environmental health by ensuring consistent water availability and quality; and reduce vulnerability to droughts, floods, landslides and pollution	SOPAC/SPC implemented, funded by the EU
HYCOS	Collecting water statistics on: average rainfall; details of water supply systems (rainwater and groundwater supplies); status of these water supply systems; and associated problems and environmental issues involved (such as over-abstraction, saline intrusion and contamination of drinking water)	SOPAC/SPC
International Waters Project (IWP)	Improving liquid waste management, including the trial and assessment of composting toilets supported by strategic communications	GEF, SPREP, UNDP
ONGOING PROJECTS		
PACC	Training and awareness-raising related to rainwater harvesting; construction of a new rainwater cistern in Lofeagai and Vaiaku; and, planned construction of 10 composting toilets	UNDP, SPREP
B-ENVELOPE	Increasing water-security in Funafuti through installation of rainwater harvesting systems, improve distribution of water, improve sanitation and provide adequate training and awareness in maintaining rainwater catchments	EU, SOPAC/SPC
GWF IWRM	Improving sanitation and water security through the installation of 40 composting toilets and associated training and awareness-raising	GEF, SOPAC

Chapter 6 Assessment of three water and sanitation projects

This section considers three water security projects underway in Tuvalu, on the main atoll of Funafuti:

- GEF PACC project;
- EU B-Envelope Disaster Risk Reduction project; and
- GEF IWRM project.

These projects are intended to target the needs of the population of Funafuti in terms of water security and water quality. The three projects share a common ground, addressing similar sets of strategies – referring, for example, to equipment maintenance, water-use efficiency and awareness-raising – as well as adopting similar principles of sustainable development. Interestingly, all projects aim to help Tuvaluans cope with the problems of water security and water quality and overlapping objectives are inevitable. However, as will be discussed, the lack of data produces limitations to the analysis of the extent to which projects overlap. Additionally, the lack of data limits the extent to which project designs and project cycles can be assessed, although these will be flagged as important issues in terms of assessing lessons learned. The economic assessments of these three projects will be conducted in the context of Funafuti only.

6.1 Introduction to the Tuvalu GEF Pacific IWRM project

Regional efforts in GEF-IWRM

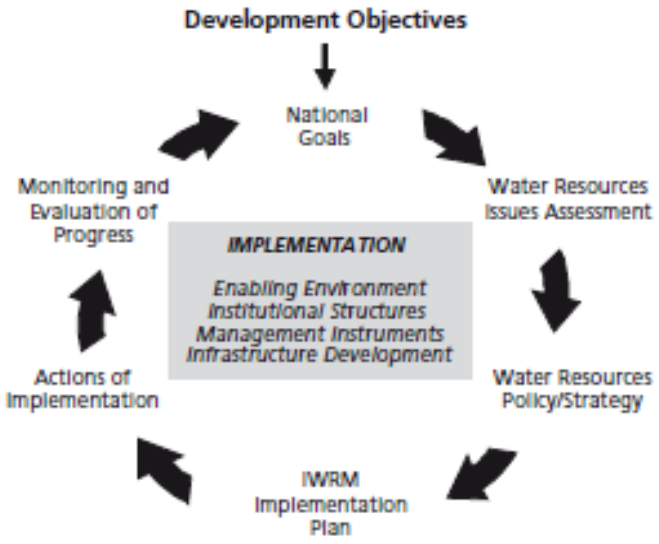
The SOPAC/SPC-implemented IWRM project is founded in the recognising of the value of integrated water management for sustainable development. IWRM was promoted at the 2002 World Summit for Sustainable Development which contained a specific global requirement to develop IWRM and Water Use Efficiency (WUE) plans, supporting developing countries, also known as the "IWRM Target" (UN-WATER 2007).

The general objectives of IWRM are to "facilitate the sustainable management of water resources by fostering information exchange and helping to match needs for solutions to water problems with available tools, assistance and resources" (Global Water Partnership (GWP) 2000, p. 8). It seeks to achieve this by providing a process to "assist countries in their endeavour to deal with water issues in a cost-effective and sustainable way" (GWP 2000, p. 8) (Figure 4).

According to UN-WATER (2007), it is clear that several developing countries still face considerable challenges in the implementation and achievement of the IWRM Target, including: lack of political will for water policy change; limited awareness of water issues; poor financing; scarce national resource allocation to water-related development; discontinued support programmes; and, weaknesses in human and institutional capacity (Marc Wilson, Manager, GEF IWRM Project, SOPAC, personal communication 2010). These issues are common to most Pacific island countries. As a result, SOPAC/SPC-executed IWRM project was established, and funds began to be disbursed, in 2009 to assist 14 Pacific island

countries 'improve water resource and wastewater management. Additionally, this project would support improvements in water use efficiency to balance overuse and conflicting uses of scarce freshwater resources through policy and legislative reform and implementation of applicable and effective IWRM and WUE plans (SOPAC 2010). This IWRM project includes Tuvalu.

Figure 4 IWRM planning and implementation stages



Source: UN-Water (2007)

The IWRM project is intended to reduce the vulnerability of Tuvalu to drought and improve human health through improved waste water management in an IWRM framework. The project is funded for five years (2008 - 2013) by the GEF with US$10.7 million and implemented in collaboration with UNEP and UNDP. It focuses on practically demonstrating and developing IWRM best practice to address national priority water issues through four key components (SOPAC 2010):

- Component C1 – country-driven and designed demonstration activities focusing on sustainable water management to utilize IWRM approaches to bring significant environmental stress reduction benefits
- Component C2 – development of an IWRM regional indicator framework, based on improved data collection and indicator feedback and action for improved national and regional sustainable development, using water as an entry point
- Component C3 – Policy, legislative, and institutional reform for IWRM through supporting institutional change and re-alignment to enact National IWRM plans and WUE strategies, including appropriate financing mechanisms and supporting and building further political will
- Component C4 – Regional capacity building and sustainability programme, including knowledge exchange and learning and replication

Overall, the aim of the GEF IWRM project in Tuvalu is that:

"At the end of the project, the Funafuti community should be more able to make well informed decisions and have the necessary skills to protect their groundwater and marine environment, and conserve and sustain their freshwater supply. With this increased understanding and acceptance within the community, the government should have a stronger mandate and more effective authority to enact the necessary regulations, codes and legislation to support integrated water and wastewater management," (Seleganiu and Moulogo 2010, p. 4).

Key activities to occur under the project include: improving rainwater harvesting through equipment provision, maintenance training and water use efficiency education; and improvements in sanitation infrastructure through the construction of demonstrative composting toilets and regular sanitation workshops. For a detailed list of activities, please refer to Annex 3.

The stated objectives of the GEF IWRM National Apex Body are:

- to ensure that the IWRM plan is endorsed and legalised by government with support for continued implementation in the long term;
- for the people of Tuvalu to have secure access to potable water; and
- for the safe disposal of wastewater (SOPAC 2007).

These objectives are in line with the recommendations that had been made, concerning increased awareness and improved community engagement (through an expansive community survey), following the previous SPREP-executed International Waters Project (IWP).

Additionally, the rainwater harvesting systems on Tuvalu are deemed to be in need of refurbishment and repair. A need has also been identified for increasing household and community rainwater harvesting systems and storage, as well as investigating and expanding the use of groundwater resources. Also identified by SOPAC (2007) is the need to strengthen the capacity of organisations, including the Public Works Department, the Meteorology Department, the Waste Management Unit, the Kaupule (Island Council) and the Public Health Division of the Ministry of Health. Associated support and training in the following areas was identified:

- water resources assessment (groundwater and rainwater), monitoring and analysis;
- integrated planning, including reference to climate variability and drought proofing;
- cost recovery and demand management strategies;
- training for plumbers and other relevant personnel on design and maintenance of rainwater harvesting systems, and design and construction of septic tank toilets and waterless zero-discharge toilets; and
- community liaison.

According to the GEF IWRM Diagnostic Report (SOPAC 2007) and the Tuvalu Demographic and Health Survey (Government of Tuvalu 2007b), in Tuvalu, there is no centralised sewerage system and 100 per cent of households depend on onsite septic tanks and flush or pour-flush toilets. The issue here is one of waste and sanitation, where increased freshwater-use in the popular flush toilet causes compound seepage from septic tanks and consequent contamination of groundwater resources. As a result, wastewater management is in the hands of the community and Integrated Water Resources Management in Tuvalu must necessarily consider community engagement. Many community members are as yet unaware of the polluting nature of presently used septic tanks and perceptions of composting toilets are quite poor, with flush toilets seeming more 'modern' and previous composting schemes having been carried out ineffectively (Seleganiu and Moulogo 2010). Given that the GEF IWRM project in Tuvalu specified that it would build 40 composting toilets with the funds available, twenty have already been built and are working. Training and awareness-raising on sanitation issues commenced at the outset during project design and, to date, awareness has been improved (Seleganiu and Moulogo 2010). Training of communities and households is crucial and the GEF IWRM Project tries to address this in Tuvalu from a variety of angles:

- demand management, including use of water-saving devices, leakage control and adaptation to climate variability;
- design, construction and maintenance of rainwater harvesting systems;
- design, construction and maintenance of effective and appropriate waterborne sanitation systems;
- design, construction and maintenance of waterless sanitation zero discharge systems, including method of treatment, advantages and disadvantages, ultimately, composting toilets; and
- water quality monitoring and protection, including use of filters and first flush mechanisms.

In considering the work of the GEF IWRM project, its links with other projects need to be recognised. While the activities noted above exist in the log frame of the project, many of the activities are co-funded or reliant on the work of other projects for delivery – in particular, the SPREP-executed PACC project and the SOPAC-executed EU-B Envelope project (David Duncan, Engineer, IWRM Project, SOPAC, personal communication October 2011).

The GEF IWRM specifies that awareness-raising activities with regards to water resources and sanitation management be conducted by the government, NGOs and community-based organisations in close association with donor-funded programmes (SOPAC 2007). The Government of Tuvalu has committed US$1.5 million co-financing in addition to US$564,000 that has already been committed by the GEF to continue to improve the retention capacity of water resources in Tuvalu.

The GEF IWRM project in Tuvalu claims that there continues to be a limited understanding of the linkages between poor sanitation, disease, degradation of the marine aquifer and environment, and the indirect and direct impacts on livelihoods and food security – despite

the efforts following the awareness-raising and education activities recommended by Lal et al. (2006). Again, the GEF IWRM project is trying to target these with community training and workshops. In addition, the need to reduce demand and conserve water was and continues to be not widely appreciated, and complex cultural and land tenure conditions limit the opportunity for government intervention by government. Continued practical training to raise awareness is being conducted to provide households with the necessary skills to take action and responsibility, in the context of the above caveats (SOPAC 2007).

To ensure sustainability of project outcomes, the GEF IWRM project provides training and capacity-building such that the Government of Tuvalu will be able to maintain this, both financially and in terms of the investment of time. For example, the GEF IWRM project conducts regular training of household members, in areas of guttering, roof-cleaning and rainwater tank maintenance (awareness raising, etc.). Although the specific expenditures by GEF on the project will culminate in 2013, it is anticipated that the government will continue to financially support this in the longer term (SOPAC 2007).

The main capacity building achievements of the GEF IWRM thus far are quarterly meetings with communities, with associated training of rainwater storage and treatment, as well as regular visits from GEF IWRM staff to check on the status of the 20 new composting toilets, and provide advice and maintenance services. These achievements partially address the aims of the GEF-IWRM: to conserve and sustain their freshwater supply with increased understanding and acceptance within the community (Seleganiu and Moulogo 2010).

Costs of GEF IWRM Implementation

For the GEF IWRM project, funds have been expended with the aims of achieving the following outputs over a period of years:

- revision of national legislation and policy;
- review of Draft Water Act and Water Policy;
- reconvene Water and Sanitation Steering Committee;
- definition of water and sanitation roles and responsibilities;
- undertake water and sanitation planning as required;
- design communication strategy, capacity building strategy, participation strategy and replication strategy;
- maintenance of continuous and up-to-date information;
- assess current status of Funafuti sanitation and wastewater impacts;
- revisit Lal et al. (2006) IWP cost benefit report;
- improve the septic systems study;
- revise the Funafuti building code to incorporate guidelines on water and sanitation;

- provide support for development of rainwater storage model and improvement of rainwater infrastructure; and
- sustained project management and other miscellaneous desk-based work.

6.2 Introduction to the EU B-Envelope Disaster Risk Reduction project

The EU B-Envelope project is a European Union facility that provides funds for building community resilience and reducing risk to disasters across eight Pacific-ACP countries, including Tuvalu. The project is implemented by SOPAC commencing in October 2007 and is scheduled to close in June 2013.

The objective of the project in Tuvalu is to improve resilience to drought and provide access to safe drinking water, focusing on Funafuti. In reducing vulnerability to disasters, specific interventions include:

- supply of rainwater catchment systems for households and communities;
- improve distribution of freshwater;
- improve sanitation; and
- training and awareness to maintain rainwater catchments and manage water usage.

In reducing vulnerability to natural disasters such as drought that are typically worsened by climate change, the project compliments the objectives of the Regional Framework for Action 2005 - 2015 in building resilience of communities, as well as the Regional Action Plan on Sustainable Water Management, addressing vulnerability of water resources and supply systems, and the Tuvalu National Strategy for Sustainable Development from 2006 - 2015 (SOPAC 2008).

The EU B-Envelope project focuses on improving household and communal collection and storage of rainwater during the dry season and droughts. The rainwater harvesting systems supplied and installed by the project include the supply of 310 polyethylene tanks (10,000 litre capacity), first flush devices, guttering, pipes and related accessories. The project targeted households on Funafuti, including catchments managed by the Kapules and Churches. Improvement in rainwater collection through repair of guttering extended to more households and other buildings that were in need of repair. To facilitate efficient distribution of freshwater during drought periods, assistance was also provided to the Ministry of Works and Public Utilities through the supply of a water tanker vehicle. The training and awareness programme entails educating households on good management practices in maintaining clean water such as cleaning of guttering and roof catchment, including conserving water usage.

Another activity of the project is promoting eco-sanitation approaches to avoid contamination of ground water and conserve freshwater usage. This activity is jointly implemented with the IWRM project aimed at identifying and promoting simple and affordable sanitary practices such as composting toilets with pilot projects in schools. Several options have been explored although no retrofitting of composting toilets has yet

been done by this project at the time of this report. Some composting toilets have already been built through other projects to demonstrate the potential benefits. More needs to be done in promoting better sanitation practices as only a handful of people are using the composting toilets.

Details of activities conducted under the EU B-Envelope project are provided in Annex 4.

Over the long term, it is expected that the target populace will show improved health, resulting from improved water supply and quality (SOPAC 2008), as well as due to reduced sewage effluent disposal. These long-term impacts are expected to improve community livelihoods through improved health, improved productivity, and improved education and reduced vulnerability to climatic extremes, specifically to drought. Household budgets are expected to benefit from reductions in health costs, desalinated water costs, and soil compost sale revenues.

Household rainwater survey

Prior to the supply of rainwater catchments, a household survey was undertaken in Funafuti. The aim of the survey was to collect socio-economic information from households, including current state of roofing catchment to identify houses that were in need of assistance. The survey was undertaken in 2009 with the support of the Pacific HYCOS project also implemented by SOPAC. A Geographical Information Systems (GIS) database was developed from the result of the survey that provided detailed information on occupants of each household, including rainwater tank/roofing/guttering status. Criteria, and usefulness, of data collected in the community assessment of households is listed in Table 7.

Table 7 GIS criteria and usefulness of data

Criteria	Usefulness of Data
Percentage of roof with gutter	To determine rainwater collection potential by fitting rainwater tank, to reduce rainwater wastage
Guttering (width, condition, type, material)	To determine rainwater collection potential by fitting rainwater tank along with improving guttering, to reduce rainwater wastage
Connection and condition of down pipes	To determine need for piping, in addition to tank and potentially guttering, to reduce rainwater wastage
Minimum, maximum and average tank size by category	Determine the volume rainwater currently available per household and how this can/should be improved
Tank outlet (bucket, pump, tap, etc.)	Determine sanitation improvements necessary in treatment of collected water
Tank water use (drinking water, irrigation, washing, etc.)	Determine sanitation requirements for household
Tank alternative water source (truck, community water storage, well, etc.)	Determine feasibility of back-up freshwater options and whether a rainwater tank is actually in demand or not
Roofing conditions (slope, tree cover, type of dwelling, material)	Determine feasibility of collecting rainwater (only a certain slope, minimal tree cover and smooth composition will be acceptable)

Tank conditions, quality of filtering gauze and the need for repair	Determine need to replace gauze for improved quality of rainwater

Costs of EU B-Envelope implementation

Funds have been expended with the aim of achieving the following outputs:

- access provided to households and communities to freshwater;
- increased storage capacity of rainwater to households and communities;
- improved livelihood and health standards;
- reduced risk to long dry periods and drought;
- efficient distribution of fresh water;
- improved conservation and usage of freshwater;
- effective monitoring of water quality;
- reduced contamination of fresh water; and
- sustainable supply of fresh water with reduced dependency on desalinated supply.

6.3 Introduction to the Tuvalu PACC project

In 2005, the Pacific Adaptation to Climate Change (PACC) project was developed to assist 13 Pacific island countries to implement adaptation measures. The project is funded by the Global Environmental Facility and has a value of US$13 million. The project is implemented regionally by the United Nations Development Programme in partnership with the Secretariat of the Pacific Regional Environment Programme (SPREP). On a national basis, specific PACC projects are implemented by the relevant departments of Public Works, in collaboration mostly with NGOs, the Ministry of Health, the Ministry of Education, the Ministry of Environment and local government groups. In March, 2011, it was suggested at the Pacific Climate Change Roundtable in Niue that the PACC process represents a framework to deliver adaptation actions on the ground, moving away from projects and building climate change adaptation into a programmatic approach. The principal objective of the PACC is to facilitate the implementation of long-term adaptation measures to increase the resilience of a number of key development sectors in the Pacific island countries to the adverse impacts of climate change. The PACC projects began in 2008 and are scheduled to continue until 2013.

As defined in the UNDP PACC project document (UNDP 2008), the PACC project objective is to enhance the capacity of participating countries to adapt to climate change and climate variability in key development sectors. Specific adaptation projects were selected after an intensive consultative process with the implementing agencies. The aims are to mainstream, demonstrate, build capacity and project manage issues of relevance to climate change adaptation.

The PACC project is intended to promote climate change adaptation as a key pre-requisite to sustainable development in Pacific island countries. PACC project focuses on three major thematic areas, namely food production and security coastal management and water resource management. As specified by the UNDP, all countries were obliged to undertake a thorough stakeholder analysis as part of the design of their national PACC projects. Consultations were undertaken in three phases:

- a regional inception workshop for the PACC project preparatory phase in Nadi, Fiji in 2006;
- individual country consultations to further define focal areas and specific activities to be addressed; and
- development of country specific implementation arrangements by local staff and across national government agencies.

Following these stakeholder engagement steps, Tuvalu is now actively developing its PACC activities, implementing adaptation measures to strengthen water resource management. A framework for PACC (PACC framework) has been developed through a consultative process, involving all relevant stakeholders, including: national governments and their respective agencies; institutions, departments and ministries; non-government organizations; CROP agencies; donor partners and, where appropriate, the private sector.

In Tuvalu, the PACC project originated out of regional Pacific discussions on climate change adaptation. The project was endorsed by the government and enacted by the Department of Public Works and the Department of the Environment. According to the Government of Tuvalu (2002), the main objective of the Tuvalu project is to increase the resilience of water resources by improving water resource management and enhancing the adaptive capacity of communities and socio-economic activities to climate change and sea level rise. It is suggested that the goal will be achieved through piloting climate change adaptation in water resources management on Funafuti Island, focusing on sustainable use and management of water resources. This will entail the implementation of non-structural (soft) water conservation and water use efficiency, as well as structural (hard) rainwater harvesting and storage improvements. Activities involved include:

- plan and conduct community-based vulnerability assessments in relation to drought events and identify adaptation options;
- develop a guide for climate proofing existing water reservoirs and water tanks, taking into consideration current and future changes in climate;
- improve knowledge of available water resources, demand and prediction of extreme events;
- develop and use climate information and data for water resources planning and management;
- design and demonstrate alternative water supply systems, using energy efficient technologies;

- expand rainwater collection schemes as a long-term strategy and a means of 'climate proofing' to cater for future droughts;
- land use planning and water reserves - protection of water storage facilities from contamination;
- establish and regulate water reservoirs or 'engineered groundwater protection/storage zones'; and
- construct an underground water cistern at the Lofeagai community church grounds and at Vaiaku.

Details of activities conducted under the PACC project are provided in Annex 5 while details of PACC activities conducted via the EU B-Envelope project are contained in Annex 4. As with the SOPAC-executed EU B-Envelope project, there are links between the SPREP-executed PACC project and the IWRM project with some of the activities of the two projects co-funding or supporting each other. For example, aside from sharing premises and committees, both projects are coordinating to develop a combined national policy framework (Dave Duncan, Engineer, IWRM project, SOPAC, personal communication, October 2011).

At the time of preparing this assessment, some details related to aspects of the PACC project were still unclear. This included the outcomes of the vulnerability and adaptation assessments, as well as the possible size of the community water cistern being considered.

The PACC, in line with the GEF IWRM project, is being overseen by the National Water and Sanitation Steering Committee, which meets every quarter to review progress of the reports. Collaboration between the two projects is scrutinised to ensure that there is no duplication of work, but maximum sharing of resources and ideas (Seleganiu and Moulogo 2010; Tausi 2010). According to the July - September Progress Report (Tausi 2010), the PACC project in Tuvalu has already used all of the funds that had initially been made available to date, and an additional US$26,475 was added, of which 68 per cent had been used by the 3rd quarter of 2010. Outcomes achieved by this quarter included: an adaptation assessment of Funafuti and Lofeagai Community; a water demand management survey, with associated GIS analysis; support of improved climate change monitoring, as well as an updated GIS model for climate change vulnerability and adaptation mapping; communication and awareness-raising on the impact of climate change on livelihoods and, technical training support.

Under the PACC in Tuvalu, specific effort was made by the Public Works Department to obtain data, such as the GIS model for climate change vulnerability and adaptation mapping. This data was used to assess rainwater (e.g. tanks and roofing) and sanitation (e.g. composting toilet) needs of Funafuti communities. Resulting assessments have not yet been communicated or released.

Costs of PACC Implementation

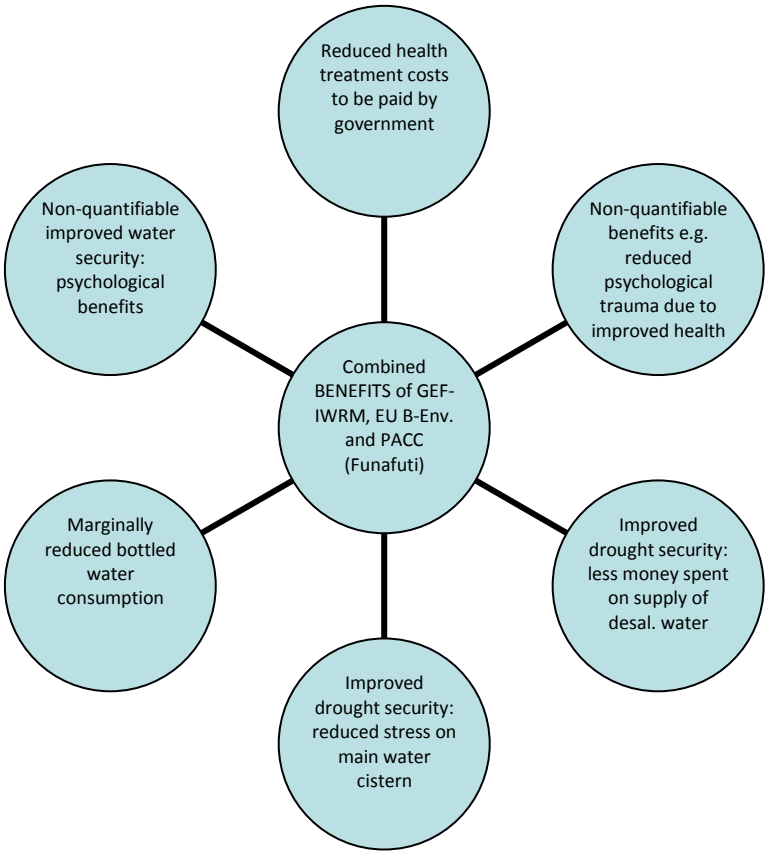
For the PACC project, funds have been expended with the aims of achieving the following outputs over a period of years:

- revision of water sector policy and incorporation of climate change risk and resilience aspects;
- development of National Climate Change Policy;
- development of guidelines to integrate climate risk into the water sector and its demonstration activities;
- identification of adaptation and demonstration, followed by implementation and monitoring of results;
- national communication and awareness plans developed and implemented;
- exchange of best practices and lessons learned across PICs; and
- establishment and operation of national project management units.

6.4 Potential benefits of the projects

Given that all three of the projects aim to enhance water access and/or quality in some form, the potential benefits to the Funafuti community of each project are difficult to distinguish. For example, all projects include objectives to improve water quality, thus addressing sanitation. However, it is difficult to identify the percentage of total improved water quality, for example, that is likely to be attributable to any one project versus another. Consequently, economic assessment of the three projects will be conducted jointly, with market benefits of the projects to be considered collectively (displayed figuratively in Figure 5).

Figure 5 Schematic of the market benefits of the projects



6.5 Commonalities and success

UN-WATER (2007) observes that the following steps that would be important for the development of adequate water-related climate change adaptation plans and projects; these are listed alongside the projects, listing whether or not a project has targeted these steps. Commonalities and overlaps that exist in any significant way, with respect to the climate change adaptation issues that have been referred to in the global literature, are clearly illustrated (Table 8).

Table 8 Commonalities between projects

Requirements according to UN-WATER (2007)	EU B-Envelope	GEF IWRM	PACC
Improving long-term resilience through strengthening institutions; planning and policy work.	✗	✓	✓
Strengthen governance and improve water management, e.g. development of governance bodies, delegation of governance decisions to appropriate levels, direct community engagement in decision-making, modifying existing processes and demands for existing water systems and users (e.g. water conservation).	✓ (through awareness raising)	✓	✓ (through awareness raising)
Leverage additional funds through (a) both increased national budgetary allocations and (b) innovative	✗	✓	✗

funding mechanisms for adaptation in water management.			
Invest in cost-effective and adaptive water management as well as new technology transfer (e.g. rainwater tanks and other technology) and maintenance, rehabilitation and re-engineering of existing systems.	✓	✓	✓

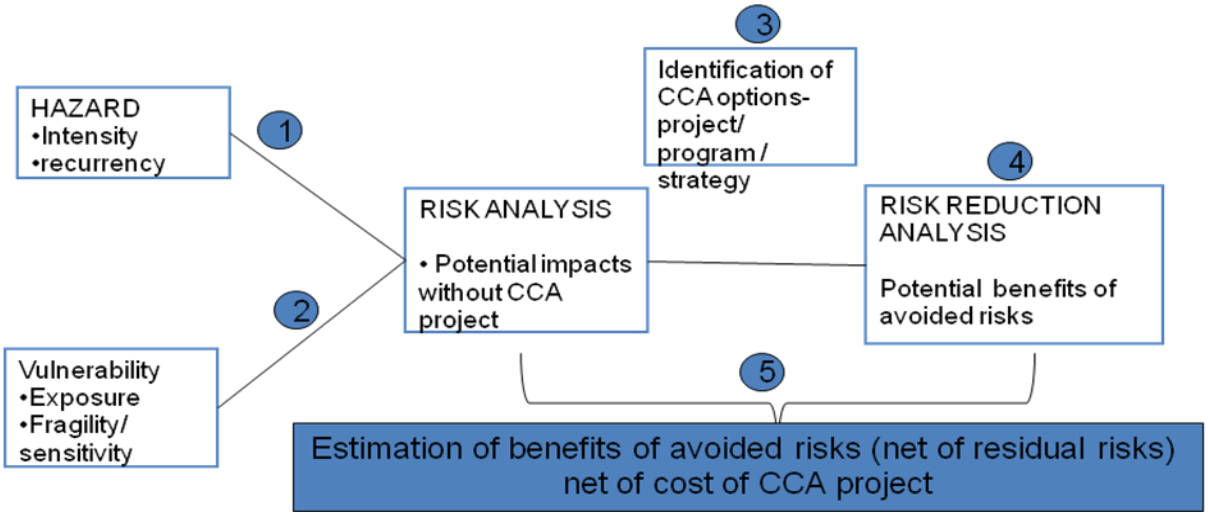
Chapter 7 Methodology

Section 2 observed that disaster risk is a product of the nature of a hazard and the vulnerability of a community. To this end, any adaptation that aims to adapt to a disaster risk such as that posed to the Tuvalu water sector by climate change must, in some way, be designed for either the drought hazard faced in Tuvalu and/or the vulnerability of the community who are exposed to the hazard. At the same time, an assessment of projects would need to take into account what might have happened if the projects had not gone ahead. As a result, the assessment of the Tuvalu water projects must take two components:

- an assessment of the how the projects were designed to address the drought risks of the community (hazard, vulnerability); and
- the implementation and consequent net economic contributions of the projects (cost benefit analysis).

Following Mehler (2005), this approach is illustrated in Figure 6. Assessment of the design of the project is described in this section.

Figure 6 Analytical framework to assess adaptation



Source: Mechler (2005)

7.1 Linking project design to threats

An assessment of how the design of projects linked to the threat of water security will be considered in the context of a project cycle. A project cycle describes the management activities and decision-making procedures used during the life-cycle of a project (European Commission 2004). Project cycles are intended to assist managers to plan and organize projects so that they are based on identified needs and have measurable impacts. Standard project cycles reflect the identification of a project through to its assessment and monitoring:

- identification and preparation – generation of the initial project idea and design
- appraisal – assessment of the project from relevant perspectives (e.g., technical, environmental)
- implementation and monitoring – implementation of project activities, with on-going checks on progress and feedback
- evaluation – periodic review of the project with feedback for next project cycle (European Commission 2004)

In practice, the names given to the different stages of a project cycle vary from organisation to organisation, author to author. For the sake of ease, the steps identified above will be used for this assessment, although they might be broken down into smaller discrete stages with different titles (see, for example, Lal and Holland 2010).

7.1 Cost benefit analysis

The economic analysis of climate change water adaptation in Tuvalu will be conducted for the PACC project, the EU B-Envelope project and the GEF IWRM projects, as examples. The analyses uses cost benefit analysis (CBA). CBA is an economic technique that evaluates the benefits and the costs of a project from a social perspective. The technical sections of this economic study will follow a methodology comprising three main steps:

- measuring the nominal gains and losses over time of a given project to a pre-determined community. Monetary values are used to measure gains and losses to a given community;
- aggregating these monetary valuations and expressing them as present social benefits and present social costs; and
- determining the overall net present gain or loss, where the 'net' value of continued investment in a given project equates to its present benefits, less its costs and is calculated by comparing the situation without the project to the situation with the project. In this report, this is referred to as a 'with and without analysis.'

An in-country visit was carried out by SOPAC/SPC between the 28th of April and the 10th of May 2011. A list of people interviewed and meetings held, and the various questions that were asked are attached in Annex 6. The economic assessment of in-key activities in the projects in Funafuti has been conducted over a 20-year time frame (2008 - 2027). This assessment will consider PACC and EU B-Envelope project expenditure as limited to the years during which SOPAC and SPREP executed the projects (and will do throughout the project life). The GEF IWRM project however, will be considered as more long term, involving investments from the Government of Tuvalu over the next 20 years (Marc Wilson, Manager GEF IWRM Project, SOPAC, personal communication, 2011). These different time projections are based on statements by SOPAC/SPC on the predicted sustainability of project activities after funding has been completely deployed.

7.2 With and without analysis

The analysis will consider the economic benefits and costs without the projects and compare this to the economic benefits and costs with the three selected projects. Because of the potential overlaps in benefits of the projects they will be considered jointly.

In this study, two scenarios will be examined from an economic perspective to determine the value of each project to the Tuvaluan people and government respectively, in terms of sustainability and risk mitigation in the face of global climate change.

Without Scenario

Water conditions on Funafuti without water projects were considered by Lal et al. (2006) who observed that a 'do nothing' approach to sanitation could cost the nation of Tuvalu around AU$475,000 per year (in 2006 values), 80 per cent of which could be attributed to health treatment costs (Lal et al. 2006). In the absence of the three projects considered here, other projects (e.g. Table 6) addressing water security in Tuvalu would still be expected to continue. Unfortunately, information on the actual contribution of these projects to water security on Funafuti does not exist. The introduction of the three projects under consideration in this analysis implies that there remains, despite these projects, a need for further work. In the absence of any information on the contribution of other existing projects, it is therefore assumed, that water security on Funafuti is still wanting but that – due to the existence of other projects – it at least remains stable. In light of this, ongoing threats to water security would suggest that the quality and quantity of freshwater available on Funafuti persist. It is possible that excessive and unsustainable use of water from available catchments and tanks by some residents would create isolated periods of water shortages, which could provide a severe threat of water security during the dry or drought seasons. Some incidence of water-borne illnesses might also be expected to continue if poor management of septic systems prevails. It is generally assumed that although relatively uncommon, water sources such as desalination, bottled water and bucket rations would continue to be consumed by Funafuti residents without the water projects.

With Scenario

With the three projects, efforts will be made to increase water security. The extent of benefits will then be dependent on the level of uptake by residents, as well as environmental conditions such as changes in rainfall and temperature, drought frequency and king-tides, which may be affected by climate change over time. If successful, the projects would be expected to generate improvements in water quality, water use efficiency or increases in the volume of water available (Table 9).

The outcomes of these effects would principally be to improve health due improved water quality and to improve water security due to improved water use efficiency practises and increased quantity. Health improvements would be reflected by fewer incidences of water-related illnesses. Water security would be reflected in reduced consumption of imported bottled water and/or desalinated water with associated cost savings. Other benefits might

include improved ecosystems in the nearshore area, reduced trauma from chronic illness, or improved water use efficiency in the future.

An important aspect of the potential benefits would be any increase in water security achieved for times of drought. During a drought period, residents in Tuvalu are forced to alternative water sources, such as groundwater or lagoon water for washing, bottled or desalinated water for drinking that they would not normally choose. The resulting health and water purchase costs 'spike' at these times. Benefits from the successful implementation of the three projects under consideration in this analysis would mitigate this and benefits might thus appear as in Figure 7. Actual values associated with the implementation of the projects will be explored in detail in Section 8.

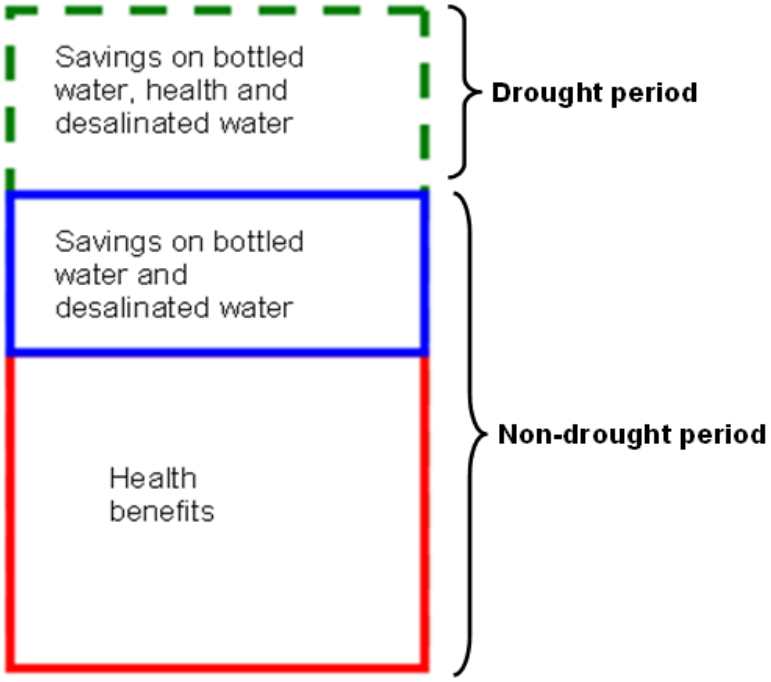
Table 9 Summary of principal benefits due to each project in Tuvalu

		Increased water supply (during drought period)	Improved rainwater quality	Improved sanitation more generally	Improved water use efficiency	Mainstreaming and governance	Awareness and education
GEF-IWRM	Provision?	NO	YES	YES	YES		YES
	Description	-	Training and awareness-raising on a regular basis on rainwater treatment and rainwater system maintenance Household basis	Composting toilets, education and awareness, training workshops	Commenced installation of composting toilets – 20 installed and 20 more to install	Identification of legislation and policy issues to be resolved in the near future, such as: engaging community support to draft the building code; review and update the draft national water policy; and, review and update draft water resources plan. The GEF-IWRM Diagnostic report (SOPAC/SPC 2007) identified the need to improve coordination between agencies. Specifically, the SOPAC/SPC (2007) mentioned the need to develop liquid waste management legislation	Rainwater tank maintenance training on a regular basis Sanitation: awareness-raising of sources and impacts of groundwater pollution, as well as hygiene (WASH) and ecosanitation (composting toilet) awareness and management
EU B-Envelope	Provision?	YES	YES	NO	YES	NO	YES
	Description	310 rainwater catchment systems and one water tanker truck to transport water	First flush devices, training and awareness-raising, through TANGO, government & relevant stakeholders	-	Training and awareness, targeting households in promoting conservation of water usage	-	Targeting Ministry of Health and other stakeholders on monitoring water quality and management of catchments
PACC	Provision?	NO	YES	YES	YES		YES

	Description	-	Training and awareness-raising on a regular basis on rainwater treatment and rainwater system maintenance at the household basis	Composting toilets and associated sanitation training at the household basis	Training and awareness-raising on a household basis	Development of National Climate Change Policy and Water Policy	-

Due to data uncertainties, estimates of non-market benefits associated with the projects – such as trauma or chronic illness related to poor water supplies – will not be attempted.

Figure 7 Schematic of project benefits



The combined benefits and costs of successful projects associated with these two scenarios are summarised in Table 10. The contribution of each project to overall benefits is not distinguished at this point due to lack of information. Nevertheless, more discussion, relating to the individual contribution of some projects to water supply increases will be noted in Section 8.

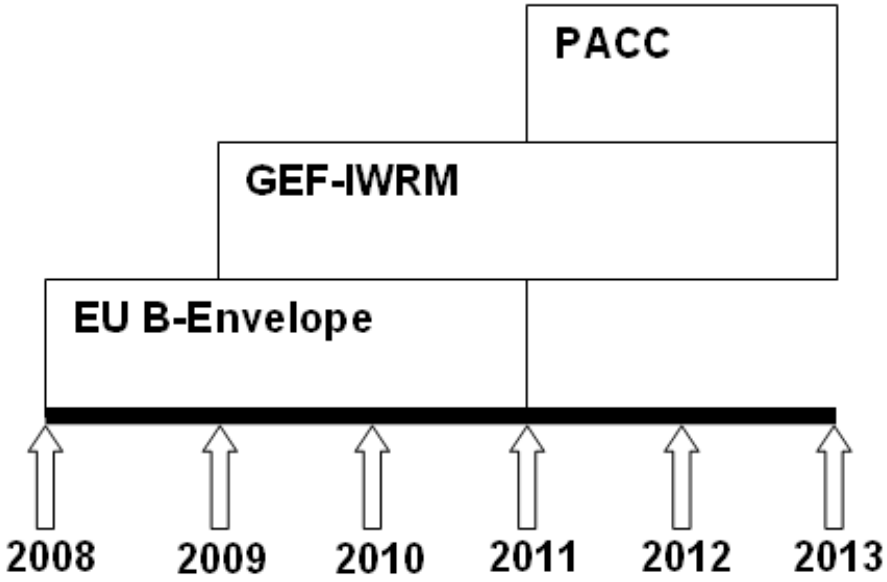
Table 10 Potential with and without scenarios and likely effects

A: Without the projects	B: With the projects (for the period 2008 - 2027)
Costs • Imported bottled water purchases • Use of expensive desalination plant • Water-borne and water-related health costs • Lack of water security and associated costs of water shortages/drought periods	Costs • Financial costs of initial project implementation and continued incremental investments over time (e.g. for maintenance and awareness-raising)
Benefits None	Benefits • Improved sanitation and associated avoided water-borne and water-related health costs • Reduced expenditure on imported bottled water consumption • Reduced expenditure on desalinated water consumption • Non-quantifiable benefits, such as psychological peace of mind due to secure water supply, reduced chronic illness, improved coastal ecosystems and potential related fishing opportunities • Sustainable supply of fresh water

Treatment of time

The three projects commenced expenditure separately, with the PACC project expenditure, commencing in 2011[4] (Taito Nakalevu, PACC Project Manager, SPREP, personal communication, November 2011), GEF IWRM project expenditure commencing in 2009 and the EU B-Envelope commencing in 2008. The EU B-Envelope project finishes in mid-2013 and the GEF IWRM and the PACC projects finish in 2013 (Figure 8).

Figure 8 Schematic of project timeline

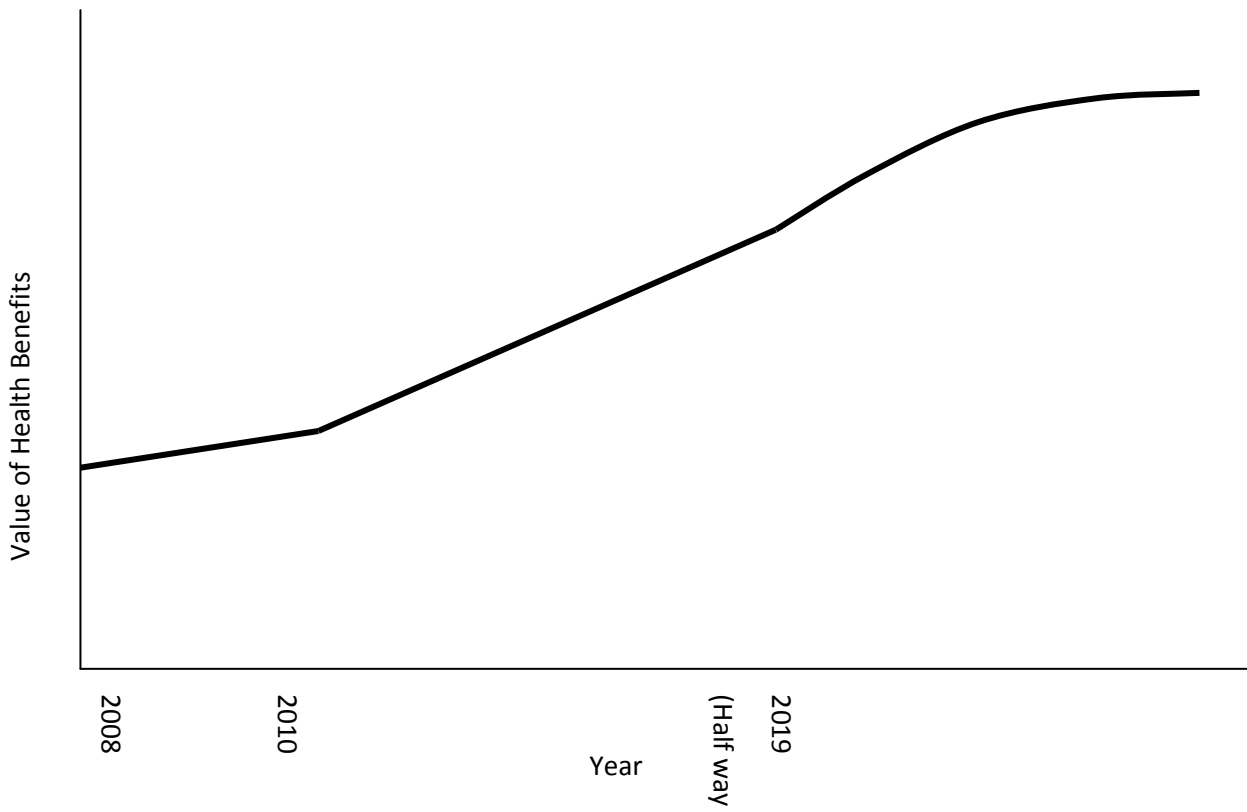


The benefits and costs of projects like the GEF-IWRM, EU B-Envelope and PACC in Tuvalu will occur over time, with ongoing costs principally comprising awareness-raising, equipment maintenance by the households themselves (after being trained by the appropriate projects) and continued national coordination. These benefits however, might change over time due to varying levels of continued investment in, and successes of, the various projects. As an illustration of these potential changes (and eventual declines) in benefits, see Figure 9.

It was indicated in Section 6.1 that SOPAC anticipates that certain activities of the GEF-IWRM project will be taken on by the Government of Tuvalu at the project's end (2013). Where these ongoing costs exist, costs will be imputed for ongoing activities post 2013 while the benefits of the PACC and EU-B Envelope projects might be expected to eventually start to tail off.

[4] Officially the PACC project commenced regionally in 2009 but disbursement of funds was delayed in some due to difficulties in recruiting national coordinators.

Figure 9 Potential changes in project benefits over time



Water supply benefits for the EU B-Envelope – in the form of reduced bottled water imports and desalinated water use – are assumed to emerge immediately following tank installation in 2008. For the GEF IWRM and PACC projects, it is assumed that the water supply benefits will also occur after commencement in 2009 and 2011 respectively, see Figure 9. The flow of health benefits of all projects are assumed to commence in 2010, allowing a sufficient time lag assumed, regarding the EU B-Envelope project. Economic analyses will be conducted over a timescale of 20 years.

Discounting

Generally, people prefer to accrue benefits sooner rather than later. In recognition that a dollar today is worth more than a dollar tomorrow, benefits and costs of the three projects are discounted to reveal their social value in present day terms. The difference between the discounted values of project costs and project benefits is presented as Net Present Value (NPV).

The rate at which later values should be discounted in comparison to earlier ones is under debate in economic literature (see, for example, Pearce et al. 2003). Woodruff and Holland (2008) indicate the range of discount values used in PICs in recent years varies between 3 and 12 per cent. Consistent with other SOPAC/SPC analyses, a discount rate of 10 per cent

will be used in this CBA, with a sensitivity analyses conducted at the rates of 3 and 7 per cent.

General economic assumptions

For this analysis, it is assumed in the first instance that all projects enjoy 100 per cent success. Health and water access costs associated with poor water security are assumed to increase over time due to inflation and population growth. Other assumptions related to project assessment are summarised in Table 11.

Table 11 Summary of general economic assumptions

Parameter	Description of assumptions
Inflation	Prices are adjusted for the change in the value of the dollar due to inflation. The latest figures available for inflation in Tuvalu are from 2008. Annual inflation was measured at 4.5 per cent which will be used throughout this report to adjust data over time where required (Government of Tuvalu 2008)
Population and population growth	This is assumed to be half of one per cent (0.005) per anum (http://www.spc.int/prism/country/tv/stats/Census%20&%20Surveys/Census_index.htm)
Time scope	This analysis represents benefits and costs of all combined projects for 20 years from 2008 to 2027
Units	Monetary values reported, using the Australian Dollar (AU$), the currency used in Tuvalu Water volumes will be discussed in terms of Litres and m^3
Pricing	Benefits and costs will be estimated at their market prices. For many items, such as equipment, this value is apparent as the market price of the items. For other items, the market price may not accurately determine resource values
Discount rate	Values are reported at a 10 per cent discount rate
National minimum wage	The average national minimum wage according to the Ministry of Labour is AU$3.38 per hour for casual workers and AU$4.12 per hour for qualified workers (Trinny Uluao, Labour Officer, Tuvalu Ministry of Labour 2011, personal communication, 2011). The overall average national minimum wage that will be used in the reporting of results will be AU$3.78 per hour
Cost of hospital treatment	The cost of hospital treatment is AU$25 per consultation, including medication. However, for resident Tuvaluans, this cost is covered by the government and only foreigners have to foot the bill themselves (Dr Nese, Princess Margaret Hospital, personal communication 2011)
Benefits of water projects in Tuvalu	Benefits will be considered in totality. It is assumed that a time lag would occur between the commencement of the projects and the generation of mechanisms (e.g. setting up the equipment) that will lead to water quality improvements. The time lag is such that health benefits will not begin to appear until 2010, two years after the start of implementation of the first project, the EU B-Envelope. On the other hand, water supply benefits will be felt as from the commencement of each project – from 2008 for the EU B-Envelope, from 2009 for the GEF IWRM and 2011 for the PACC

Complementary nature of project goals and benefits	Benefits are assumed to be common to all projects though, in reality, this might be in differing proportions. However, this study will be unable to consider these proportions due to data limitations

Sensitivity analysis

Sensitivity analysis of various factors, including discount rates and population growth will be examined both in Section 10 and further details can also be found in sensitivity analyses, used to provide decision makers with more robust policy implications. The results of the sensitivity analyses for this study can be found in Section 10.

Chapter 8 Data

The overall approach of this study involved an assessment of the project processes, to demonstrate lessons learned, and a CBA to demonstrate economic benefits.

8.1 Sources of Data

Numerous types of data were used during this study, including:

- published reports, journal articles, government reports;
- consultations with government representatives, communities affected by each given project and counterparts at SOPAC/SPC, SPREP and in Tuvalu; and
- online journals and project documents and spreadsheets.
- A summary of data collected for the cost benefit analysis of the projects is given at Annex 7.

8.2 IWP

According to Lal et al. (2006), poor liquid waste management in Funafuti cost the country over AU$500,000 per year, where the effects on human health due to key water-borne diseases accounted for about 80 per cent of this cost. Other components of this cost were expenditure on alternative water sources (Lal et al. 2006, Table 12).

Table 12 Costs of poor liquid waste management in Funafuti in 2006

Component	Cost under different assumptions		
	High	Best	Low
Human Health	452,630	395,807	284,749
Desalination	49,961	37,470	12,490
Rainwater	44,584	27,020	-
Bottled water	14,676	9,784	4,892

Source: Lal et al. (2006)

8.3 Groundwater

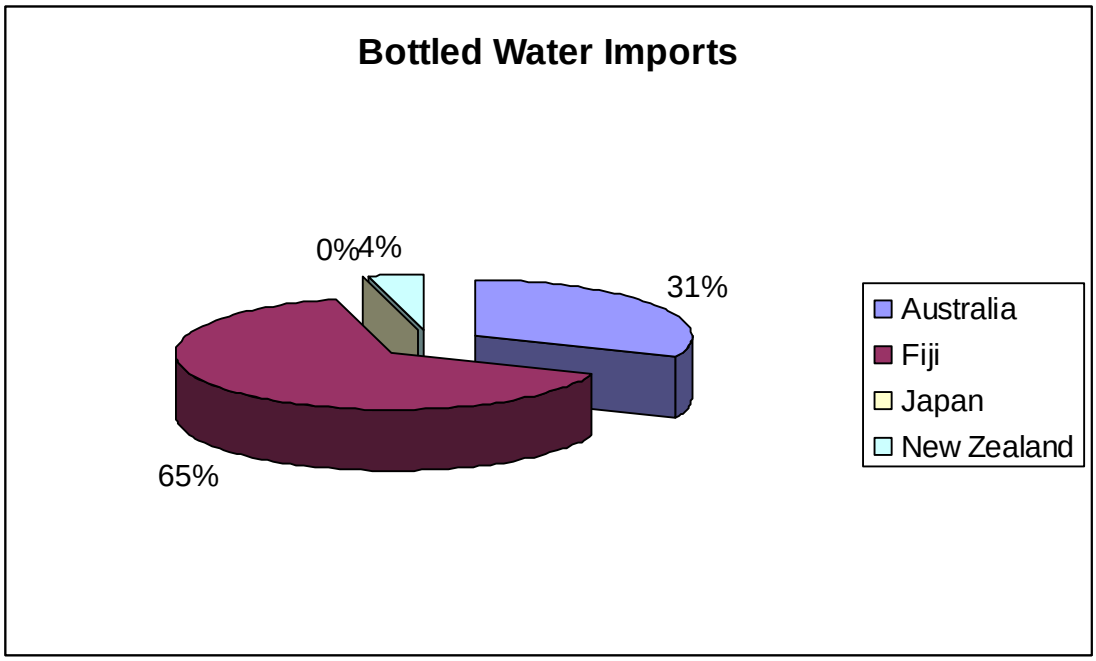
On Funafuti, groundwater is so brackish and polluted that it is only used for feeding pigs, washing pig pens and flushing toilets (Baarsch and Nguyen Berg 2011). During droughts, when there is insufficient rainwater, groundwater is used also for washing clothes and bathing). During king tides and storm surges, contaminated groundwater seeps to the surface, which may lead to unhealthy human contamination (Baarsch and Nguyen Berg 2011). Contamination may also seep into the lagoon and coastal waters, polluting these with pathogens. Data on the extents of these events was unavailable.

8.4 Bottled water

Bottled water, usually imported from Fiji, is not typically used as an alternative to rainwater in Tuvalu. Following numerous consultations with community representatives and members

of the government, it appeared that one of the only reasons people tended to buy bottled water was to subsequently use the physical bottles as containers for boiled rainwater. For the year 2010, it was reported that Tuvalu imported a total of 24102.4 litres of water at a total estimated retail value of AU$ 17423 from a variety of countries as shown in Figure 10 (IWRM 2007).

Figure 10 Bottled water import sources



8.5 Costs of water projects in Tuvalu

Two forms of costs are incurred to execute the three water projects under consideration in this assessment: fixed and variable. In the case of all three projects, budgets for project duration were fixed and assigned project expenditure was used to reflect project costs. Additionally, in the specific case of the GEF IWRM project, this project is intended to secure ongoing financial support after current donor funds have been completely disbursed (post 2013) to maintain project outcomes through awareness raising, managing a water steering committee and monitoring. The ongoing costs of these long-term activities under the GEF IWRM are adjusted for inflation after 2013. These ongoing GEF IWRM costs will be considered over the 20-year time frame of 2008 - 2027.

Costs of GEF IWRM Implementation

The total funds that have been made available to the GEF IWRM project in Tuvalu amount to AU$564,000.

Thus far, only just over AU$320,000 has been spent on the project, mainly in the planning phase. According to SOPAC/SPC (Marc Wilson, Manager GEF IWRM Project, SOPAC, personal communication, 2011), the project objectives and outcomes will be continued in the long term through government uptake after the full disbursement of project funding from the

GEF. Therefore, the costs of this particular project, in contrast to the other two, will continue over time and will be affected by inflationary pressures. This has been taken into account in the analysis.

The stream of costs arising from the IWRM until its official end were added to a stream of costs assumed to cover the cost of maintaining project awareness-raising, water steering committee and monitoring afterwards (see paragraph 8.5) Combined, the total discounted costs of the GEF IWRM project over the next 20 years would amount to just under AU$1,213,445.

Costs of EU B-Envelope Implementation

The total costs available for the EU B-Envelope in Tuvalu amount to €700,000, €526,971 of which has so far been used.

Costs of PACC Implementation

The total funds available for PACC implementation in Tuvalu amount to around AU$750,000. Thus far, over AU$300 000 has been used (Loia Tausi, PACC Project Coordinator, Government of Tuvalu, personal communication, November 2011).

8.6 Current Health Costs in Tuvalu

Treatment costs

Health treatment is free for Tuvaluans in Tuvalu. Data on the cost of treating water-borne diseases specifically was collected directly from the Princess Margaret Hospital on Funafuti. Both admissions and out-patient data were considered, for the years of 2011, 2010 and additionally for admissions data from 2009 and 2008, taken into account. Although data is sorted by the 'Home Island' of the patient concerned, it is difficult to determine which of these patients contracted the illness on Funafuti itself (residents) or on their home island (visitors). A sensitivity analysis will be considered in this regard, to account for the possibility that some individuals might not come from Funafuti and might thus not benefit from the projects being assessed.

According to discussions with representatives from the Princess Margaret Hospital in Funafuti (Dr. Nese, personal communication 2011), any given visit costs the government AU$26, for both consultation and medication (Dr. Nese Ituaso-Conway, Funafuti Princess Margaret Hospital, personal communication, 2011). The patient, if a national of Tuvalu, does not sustain any charge to visit the doctor. The duration of the visit depends on the time of day and the day of the week.

The total cost of one-stop treatment to the government for water borne diseases on Funafuti in 2010 was AU$30,576. The cost to the government of keeping admitted patients in hospital was estimated, using the available data. This estimation was based on the total AU$1,180,000 provided to the hospital in 2010 by the Ministry of Health. From this, the cost of 1176 one-stop visits from Funafuti residents was deducted for the same year, where each visit cost AU$26 (AU$30 576). After the subtraction, the approximate value that remains reflects to the cost to the government of keeping admitted patients in the hospital. During 2010, this was under AU$1,150,000 (314).

Lost productivity

The average national minimum wage for casual labourers is AU$3.38 per hour and for qualified labourers this is slightly higher at AU$4.12 per hour. The overall average hourly wage in Funafuti of AU$3.78, which is the figure used in calculation and for reported values in Section 9. The economic cost of patients being admitted to hospital for a range of water borne and water-related diseases was estimated by multiplying the average number of days admission per person per year, by the daily minimum wage and by the number of patients admitted in 2010. The number of patients admitted to hospital with water borne or water-related illnesses in 2010 was 187 and the average number of days spent in hospital per person was 7.2 days. Assuming a typical working day of eight hours, the average national minimum wage per day was AU$30.2 per person. The total lost productivity due to admitted patients in 2010 was therefore, estimated as just under AU$40000 (Table 13).

Table 13 summarizes the total health costs in Funafuti in 2010, including treatment cost and productivity losses for both one-stop visit and admitted patients with water-borne or water-related illnesses. The potential avoidance of these costs as a result of project successes ultimately defines the project benefits.

Table 13 Health cost types and associated values in 2010 (only for water-borne and water-related diseases)[5]

Type of health cost	Value (AU$)
Cost to government of one-stop visits from Funafuti	30,576
Cost to government of admitted patients	1149424
Cost to economy (lost productivity) of admitted patients	39551
TOTAL	1219551

It is important to acknowledge that some water-related health problems and associated costs on Funafuti might be linked to poor hygiene and/or inappropriate sanitation practices rather than exposure to unsafe water. The proportion of water borne illnesses due to this is not known and health professionals in Tuvalu were not prepared to make an educated guess at the proportion, based on experience. A sensitivity analysis around health benefits from the water projects will thus be conducted in order to account for this uncertainty.

In this economic analysis, the types of illnesses that have been considered (for both admitted and one-stop visit patients) and their associated causes are listed in Table 14.

Table 14 Some water-related and water-borne health hazards considered

Water-borne/water-related illness	Cause
Gastroenteritis	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Conjunctivitis	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Skin infection	Reduced water quality due to pathogenic contaminants or

[5] NB: Only people of working age have been considered in these calculations.

	inappropriate treatment/storage
Sepsis/abscesses (non-diabetes-related)	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Hepatitis A	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Tuberculosis	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Cellulitis subcutaneous infection	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Vomiting	Reduced water quality due to pathogenic contaminants or inappropriate treatment/storage
Renal stones	Reduced access to potable water supplies due to salinisation
Dehydration	Reduced access to potable water supplies due to salinisation

According to UN-WATER (2007), up to 88 per cent of diarrheal illnesses globally are caused by unsafe water. Hutton and Haller (2004) suggest that improved water supply reduces diarrhoea morbidity by between 6 to 25 per cent, if severe outcomes are included. The actual benefit to Funafuti of improved water security is not known. As a result, an average reduction in diarrhoea morbidity of 15.5 per cent (the average of 6 to 25 per cent) is assumed in the absence of better information. In this case, health costs avoided due to successful water projects would generate nominal savings in avoided water-borne/water-related health costs over time, amounting to around AU$5.3 million for all projects, allowing for an annual population growth of 0.5 of one per cent. As some of the health costs without the projects may not be avoided, even with the projects (e.g. those health costs that arise due to continuing personal hygiene and food practices), a sensitivity analysis will be conducted around health cost savings to account for this in Section 10.

Due to data uncertainties, estimates of non-market health benefits associated with the projects – such as trauma or chronic illness, related to poor water supplies – were not attempted.

Water supply benefits of projects: reduced bottled water consumption

According to interviews during the SOPAC/SPC 2011 mission to Tuvalu, it became apparent that the local population does not purchase much bottled water, relying instead on boiled rainwater for drinking and cooking. Nevertheless, since 24,100 litres of bottled water were purchased locally in 2010, successfully executed projects might be expected to increase potable water supply and reduce the interest in purchases of bottled water.

At present, future expenditure upon bottled water is not known. The population increase in the country is small but water supplies remain scare. As a result, an annual decrease in bottled water purchases of three per cent per year is assumed for illustrative purposes to demonstrate the potential value of avoided water purchases following the successful implementation of all three projects on Funafuti. Sensitivity analyses will be conducted on this issue given that the incremental decrease in bottled water savings is a proxy value, based on the Gerber (2010) study of the Marshall Islands.

Overall, the store value of bottled water purchased in 2010 was AU$17,400. The total discounted value of reducing bottled water purchases by three per cent over the 20-year time frame is around AU$12800. Insufficient empirical data was available for the following issues, which are nonetheless, important and need to be flagged:

- the fact that bottled water consumption might not be constant throughout the year, increasing during the three-month drought season (see Section 9); and
- the fact that it is difficult to distinguish the destination of the bottles imported to Tuvalu, i.e. whether they remain in Funafuti for consumption or are sent to the outer islands, given that this study only focuses on Funafuti.

Due to the relatively insignificant nature of bottled water purchases for the local population of Tuvalu, it will be assumed that bottled water purchases, once reduced following project implementation, will remain at lower levels, irrespective of whether or not the project activities are sustained.

Water supply benefits of projects: reduced desalinated water consumption

The EU B-Envelope project directly contributes to increased supply of water through the provision of rainwater tanks, by a volume of 3.1 million litres (310 tanks at a capacity of 10 000 litres each). Given that the cost of producing desalinated water on Funafuti is presently around AU$17/m^3, this suggests that the value of water capacity (saved) in the EU B Envelope water tanks might nominally approach AU$ 1 million over 20 years. In fact, the value of water supplied from the tanks would be expected to be higher since tanks would not be expected to be filled and used only once, but replenished through rainfall over the course of the year and used so long as they are available. Since SOPAC were unable to provide information on the likely supply of each tank over the course of the year (compared to capacity alone), the value of AU$1 million (nominal) for water tank benefits is therefore rather conservative.

Additionally, the PACC project in consultation with communities will be increasing water storage capacity potential for the village of Lofeagai through a community water cistern. Discussions with SPREP (Taito Nakalevu, PACC Project Manager, SPREP, personal communication November 2011) indicate that the size of this tank awaits design which means that the value of water provided by this activity cannot be determined. Estimates of water supply savings from the combined projects is therefore, likely to be underestimated.

Additionally, the PACC and GEF IWRM projects support water supply through work in awareness-raising and training on water use efficiency and improved roofing and guttering maintenance, as well as the installation of water-conserving composting toilets. The effective use of composting toilets has been identified in the past as critical to sanitation benefits, with Lal et al. (2006) suggesting that installing and using composting toilets across Funafuti could generate benefits in the order of AU$2 million, compared with incurring health costs of AU$111,821 (in current day prices). Having said this, questions about the ability of composting toilets to make a difference on Tuvalu have been questioned with Lal et al. (2006), observing the relatively low social acceptability of composting toilets in the mid

2000s. Nevertheless, efforts by the projects to introduce more conventional-looking composting toilets have been shown to improve acceptability.

The present IWRM demonstration composting toilets are still part of an awareness and education phase and these are still limited to 20, the final expected number of toilets being 40. Estimation of potential benefits from the use of composting toilets was conducted on the basis of expected water use for toilet flushing per day. There are an average of seven people per household in Tuvalu. Assuming that the average person uses around 20 litres of water for flushing per day (see http://www.csgnetwork.com/waterusagecalc.html), average flushing per household would be in the order of 140 litres per day. At a desalination cost of production of around AU$17/$m^3$, this means that toilet flushing per household could cost the Tuvalu economy around AU$869 in otherwise useable water per year[6]. Assuming that the present 20 composting toilets established under the projects are successfully extended to 40 by their end, this would suggest nominal water savings could be achieved from the IWRM project on Funafuti of AU$ 600 000 over the 20-year span of this assessment. This, of course, relies on how well the participating families adopt the toilets.

Using the same approach, the proposed 10 composting toilets under consideration for the PACC project could generate nominal water savings in the vicinity of AU$133 000.

In practice, supply improvement benefits to be achieved through the projects over the long term might taper off in the long run (for all projects except the GEF-IWRM) as new practices established through training are forgotten and/or the supply systems improved/installed fall into marginal disrepair and require maintenance. To account for these potential changes, it is assumed that supply benefits of the EU B-Envelope and PACC project could taper off after around 10 years from 2019 by three per cent per year. This value is purely illustrative but is intended to reflect the fact that infrastructure can be expected to deteriorate over time and will – without financial and time investment – lessen in effectiveness.

It should be recognised that the demonstration composting toilets provided under IWRM and intended under PACC might be expected to lead to increased demand across Funafuti for more composting toilets in the future, leading to further water savings. This reflects the fact that the projects are intended to leverage activities in the future. The value of benefits to be leveraged through projects inspired by the projects considered here have not been estimated as part of this assessment due to lack of data on future project take up.

Non-market benefits

During consultations conducted as part of this analysis, a variety of other costs have been identified arising as a result of limited water security in Tuvalu. These include psychological trauma arising from chronic health problems and the stress of water collection. For example, time wastage, and some fights breaking out between people queuing for water at the Kaupule cisterns, and there is extreme tension between local Funafuti residents and residents who originally come from other islands; people born in Funafuti typically see themselves as having more rights. Although these costs are difficult to measure, any

[6] 20 x 7 x 365 x 17/ 1000 = 869

reduction in them due to improved water security could be important. Nevertheless, due to limited data, attempts to estimate any savings in these intangible costs as a result of implementing the three projects were not attempted.

Likewise, potential benefits may arise in the quality of the nearshore lagoon system as a result of improved water quality. The quality of the nearshore lagoon system is negatively impacted by poor water quality as a result of sewerage. The introduction of composting toilets through the projects would have a direct impact on the level of sewerage flowing into the lagoon (David Duncan, Engineer, IWRM project, SOPAC, personal communication, October 2011). Reduced pollution would be expected to positively affect fishing opportunities by increasing catch per unit of effort and increasing well being. Nevertheless, no attempts to measure these values were made in this analysis due to lack of data.

Finally, the GEF IWRM and PACC projects are intended to be 'catalysing' projects which encourage resource use efficiency through their policy and institutional change work. Policy changes achieved through these projects could be expected to generate dynamic increases in benefits over time. For example, legislation through the projects that require all future houses to include composting toilets will have an ongoing benefit in the form of improved water use efficiency (reduced water demand, allowing for increased supply for households). Due to limited data, attempts to estimate any savings in these intangible costs as a result of implementing the three projects were not made.

Table 15 Summary of potential project benefits

Potential benefits	Value over 20 years AU$	Comment
Reduction in bottled water imports (e.g. 3%)	12 766	
Water savings through composting toilets	732 469	PACC and IWRM projects
Water supply increases through the establishment of tanks	987 071	EU-B envelope project Likely to be highly conservative estimate
Water supply increases through the establishment of communal tanks	Not estimated	PACC project
Health benefits (15.5% reduction in incidence of disease)	5 297 748	Assuming ongoing population increases at 0.5 of one per cent per year Could be overstated as not all water-related diseases arise from poor water (e.g. could be from poor sanitary practices)
Reduced incidence of chronic illness	Not estimated	
Improvement in nearshore lagoon and fishing opportunities	Not estimated	
Reduced stress and improved peace of mind	Not estimated	
Instigation of other relevant activities through demonstration and catalysis	Not estimated	Could be substantial

Chapter 9 Project cycle considerations

Section 7.1 observed that an assessment of how well projects were designed to target the threat of drought would be considered from the perspective of a project cycle. Several stages were to be considered:

- identification and preparation – generation of the initial project idea and design
- appraisal – assessment of the project from relevant perspectives (e.g. technical, environmental)
- implementation and monitoring – implementation of project activities, with on-going checks on progress and feedback (European Commission 2004)

9.1 Project identification and preparation

Links with national priorities and identification procedures

The three projects were designed with the intention of addressing national priorities related to water security and water quality, within the context of international climate change adaptation discussions. As discussed in Sections 3 and 6, there are significant commonalities between these global and national priorities and overlaps between the different projects are to be expected. The GEF-IWRM targets both national water security issues and water quality issues and, as a result, it targets many of the aims outlined by the DRM NAP, the NAPA and the NSDS. The projects build explicitly upon the findings of previous projects (selected recommendations of the SPREP-executed IWP).

In order to identify project objectives, the GEF-IWRM project conducted a detailed diagnostic analysis in its project design phase. This included assessment of existing threats and recommendations from previous projects, including the, then, recently completed SPREP-implemented International Waters Project. This specific project had focused on water management, including the promotion of composting toilets for water use efficiency and had recommended further work on this activity.

The IWRM diagnostic analysis ultimately led to the identification of water sanitation issues that would be worsened with climate change, such as septic-tank leakage. Priority actions, such as installation of composting toilets, were then proposed. Community input to consider the nature and design of the project from this perspective was achieved through numerous community meetings and training activities. Although the GEF-IWRM was partially established to learn from and build on the findings of the SPREP-implemented IWP, issues such as institutional and legislative change were targeted.

The EU B-Envelope project is principally a disaster risk reduction strategy, and is therefore consistent with the Tuvalu DRM NAP. However, because of the inherent overlaps between the hazard of water scarcity and sustainable development and climate change, this project also indirectly addresses aspects of the NAPA (especially themes three and four) and the NSDS due its inclusion of work to increase rainwater collection capacity on Funafuti.

To inform its design, the EU B-Envelope project conducted a detailed GIS community survey in its initial stages, generating baseline information on existing rainwater collection systems and proposing how best to add to this. Consequently, the EU B-Envelope has allowed for both the provision of rainwater tanks and support for maintenance of structures that already exist. The EU B-Envelope targeted households and community groups through awareness-raising campaigns (such as radio programmes and announcements), including training of health workers and key personnel in monitoring water quality. So far, the EU B-Envelope tanks have all been installed and training on maintenance, water use efficiency and sanitation issues is still ongoing, though evidence on the success of these is not communicated effectively.

The PACC project directly addresses climate change water priorities in Tuvalu, as articulated in the Tuvalu NAPA and the PIFACC. However, because of the overlaps and commonalities in Funafuti between climate change, natural disasters and sustainable development, this project also addresses disaster risk issues. For example, and similarly to other projects, the PACC aims to build resilience to climate change by way of increased rainwater collection capacity on Funafuti to cater for the long, dry periods.

According to SOPAC (Dave Duncan, Engineer, IWRM project, SOPAC, personal communication, October 2011), the SPREP-executed PACC project has been, in part, designed to complement the GEF IWRM project but, due to a complex range of project issues, was subsequently redefined. As it presently stands, the project still works closely with the SOPAC-executed IWRM project and complements its works. The two projects share offices, meetings, committees and information. SOPAC advises that the GEF IWRM project team implements a considerable amount of core work associated with the PACC project, not least since the two projects are complementary. Key to this collaboration is that both the PACC and the IWRM projects are coordinating to develop a combined national policy framework (Dave Duncan, Engineer, IWRM project, SOPAC, personal communication, October 2011).

Essentially, the SPREP-executed PACC project targets institutional change, stating outright its objective to develop a National Climate Change Policy and to revise the National Water and Sanitation plan. Community engagement during the implementation phase of the project was focal, involving regular quarterly meetings with community representatives. For example, consultations with the community on their preferred adaptation option resulted in the community, as a whole, agreeing for the PACC project to provide them with a community reserve that might supply them during extreme events (Taito Nakalevu, PACC Manager, SPRP, personal communication October 2011). Additionally, an extensive GIS survey of households in Funafuti was conducted during 2010 and 2011 in tandem with the Department of Public Works (Loia Tausi, PACC Coordinator, Government of Tuvalu, personal communication 2011). However, there was not enough data available at the time to be able to draw conclusions on the usefulness of this survey in achieving outputs[7].

[7] It has since emerged that data is available in the form of GIS information, from SOPAC.

Compared to the situation analyses conducted as groundwork for the GEF IWRM and EU-B Envelope projects, the preliminary assessment work to determine the nature of the PACC project in Tuvalu was determined by the larger United Nations project description which defined the timeline output areas at the regional scale. Although this document specified stakeholder consultations that should be conducted, relatively little project design was actually done on the ground in Funafuti (UNDP 2008) and the project structure was taken directly from the UNDP project document (UNDP 2008).

For the most part, the three projects considered in this document could be interpreted as targeting enhanced resilience of the local community to risks, acknowledging the vulnerability faced by the community and working to address local priorities.

Despite their apparent complementarity and close links, the Government of Tuvalu considers that, while all three water security projects target the same goal, they were largely designed independent of each other in Tuvalu, with little coordination of objectives at the initial stage (the project proposal stage), despite being developed around almost the same time (Loia Tausi, Tuvalu PACC project coordinator, personal communication 2011). By comparison, project managers actually draw attention to the shared premises, committees and coordinated work of the three projects (David Duncan, Engineer, IWRM Project, SOPAC, personal communication October 2011).

Nevertheless, the fact that the government has a perception of limited cooperation between the projects suggests that the potential combined benefits of the projects might be higher – or at least confidence in securing those benefits might be higher – if communication about the level of project coordination is improved.

As a result, future adaptation projects in the field of water security might want to consider raising the profile of their coordination with other projects (and certainly, ensuring it happens during execution) to optimise benefits. This activity might – in the case of Tuvalu – be supported in the future if a Water Coordination Body is, at some point, established. The Government of Tuvalu (Loia Tausi, Tuvalu PACC project coordinator, personal communication 2011) observes that no such body at present exists since water supply in Tuvalu is mostly a private exercise with families drawing on rainwater for their needs. Nevertheless, consultations conducted throughout this assessment indicate that many government officials are in favour of an official Water Coordination Body. It is recommended in future projects that support be given to develop this, which would be especially useful during the project planning and execution phases.

Table 16 Decision-making processes involved in projects

	INSTITUTIONAL SUSTAINABILITY		ECONOMIC SUSTAINABILITY		STAKEHOLDER CONSULTATION		
Project	How donors approve projects	Who makes decisions in Tuvalu	Consultation in design process	How are the projects coordinated	Interaction across sectors, and how	Interaction regionally/internationally, and how	Community engagement
GEF-IWRM	Follows a diagnostic analysis, written in collaboration with SOPAC/SPC	GEF IWRM employees at Public Works Department Also, project steering Committee and national APEX body	Economic recommendations of IWP Diagnostic analysis National consultations	Regular reporting back to the SOPAC/SPC GEF IWRM team and achievement/knowledge exchange in regular regional meetings through a project/steering committee and national APEX body	The project aims to use lessons learned to inform the PACC project (twinning and sharing with the Caribbean IWRM project)	Lessons learned shared with other GEF IWRM countries across the Pacific and with the EU IWRM project.	High community engagement with regards to general installation and training in use of composting toilets
EU B-Envelope	Country Implementation Plan designed by SOPAC/SPC for the EU Economic results from the IWP projects were also considered in this project	James Conway, EU representative and Secretary for Public Works Department	Economic results from the IWP projects were mentioned in the Country Implementation Plan	Reporting done every six months to the EU and annually. SOPAC/SPC also report to the Project Steering Committee	Collaboration with government agencies such as the Public Works Department as well as local NGOs and TANGO One of the	Lessons shared with other EU B-Envelope countries through reporting, however, information on project achievements to date may benefit from additional communication	Indirectly through TANGO collaboration

					key aims of the project is to achieve more integrated institutional factors		
PACC	UNDP provide an umbrella project description to all countries participating in PACC; this then edited and adjusted on a country-by-country basis in collaboration with SPREP	PACC employees at the Public Works Department	Vulnerability & Adaptation Assessment and Socio-Economic Assessments have commenced but yet to be documented and shared Intensive community survey in 2009, the results of which were used to create a Geographical Information Systems (GIS) to inform tank deployment and maintenance requirements	National PACC projects are obliged to report back to the UN on a quarterly basis	Collaboration with GEF-IWRM, in terms of lessons learned, and other government agencies	Develop National Climate Change Policy and to revise the National Water and Sanitation plan Lessons shared with other PACC countries, with PIFACC and with the UN	Regular meetings with communities for training on water and sanitation issues Consultation on project design was not stipulated, specifically in published reports

9.2 Appraisal

In conventional project cycle management, a project would be assessed prior to implement from a variety of perspectives. These might be economic, financial (such as if there was an income generation component), environment (such as where large scale construction is involved) or gender-related (depending on the nature of the project). The degree to which the different projects employed ex-ante assessments of project design before implementation varied.

First, scientific assessments varied. In some cases, assessment was extensive with the EU-B Envelope project conducting a GIS community survey to provide baseline information on existing rainwater collection systems and how best to add to this. Additionally, the GEF-IWRM project design was built on a diagnostic analysis of water problems in Tuvalu, although – due to the lack of data – evidence arguably still needs to be found that the socioeconomic information generated during this stage has yet been used in any systematic way to inform the project design and objectives.

Additionally, with the exception of GEF-IWRM project – whose design was informed by the IWP, including a socioeconomic assessment of sanitation work on Tuvalu at the initial stages of the project – the projects did not appear to reflect any economic analysis of project interventions before proceeding. As will become evident in the economic assessment of this document, this led to problems in quantitatively demonstrating the potential benefits of the project since it meant that no economic baseline data was generated from which to measure project outcomes. Had this been conducted, issues related to data gaps (see below) and the sustainability of project outcomes could potentially be considered more explicitly.

The extent to which socioeconomic or scientific assessment was used to inform the design of the PACC project is unclear as a result of a lack of available documentation (socioeconomic and vulnerability/adaptability assessment documents had still not been compiled at the time of writing and is still not available). While requests have been made to understand the selection of the design, construction and location of water tanks, it has not been possible to access clear answers at this point. For example, data from the PACC vulnerability and adaptability assessment is expected to be used to assess rainwater (e.g. tanks and roofing) and sanitation (e.g. composting toilet) needs in Funafuti when the project is implemented (Taito Nakalevu, PACC Manager, SPREP, personal communication, 11/10/2011), although precisely how this will be used also remains unclear at this point.

The absence of documentation on socioeconomic and vulnerability, and adaptation assessment findings is important since there appears to be some uncertainty by the Government of Tuvalu on different aspects of the proposed PACC activity. For example, the Government of Tuvalu has expressed some uncertainty about the appropriateness of the present site of the Lofeagai communal rainwater cistern. Loia Tausi (Tuvalu PACC Project Coordinator, Government of Tuvalu, personal communication 2011) suggests that no EIA was conducted prior to the establishment of communal cisterns under the project with the result that the Lofeagai concrete communal rainwater catchment (scheduled to be completed by the PACC project 2012) might be susceptible to contamination from the lagoon during king tides (it will be located in a low-lying zone). These concerns may or may

not be well founded. Release of final documentation on the socioeconomic and vulnerability and adaptability assessments will provide valuable evidence on the rationale behind site selection. Additionally, an environmental assessment may allay concerns and provide support for the project design.

9.3 Project implementation and monitoring

All three projects are underway and are at various stages of completion. The EU-B Envelope project is due to end in 2011 while the other two projects are not planned to cease as externally supported projects until 2013. The PACC is underway; however, concrete activities have yet to be implemented.

Monitoring for the projects is conducted regularly with all projects subject to regular donor and key stakeholder reporting. Reports reflect expenditure made and achievements made (activities completed, planned, etc.) to date.

While this monitoring is conducted, quantitative assessment of project impacts is not conducted at this point as far as can be understood. This may be because:

- baseline data against which to measure project achievements is limited (e.g. often fundamental information against which to measure improvements in water security is limited. For example, it is not possible to establish the number of patients developing water-based illnesses as a result of local water consumption compared to those who develop complaints from consuming water elsewhere. As a result, the potential reduction in patients arising from improved water society on Funafuti is unclear. Additionally – or possibly as a result of such data gaps – many project indicators for the three projects were process in nature (work completed). The contribution of the projects to human development is therefore, not conducted at this point; or equally likely
- data on environmental impacts will be difficult to collect during the life of the projects, given (i) that projects are still only underway or commencing (ii) the timeframe of the projects is short while environmental impacts can be expected to take place over the medium term

The absence of baseline data against which to measure the water projects confounded economic assessment of the projects. For example, absence of baseline data on Funafuti residents likely to benefit from improved water security makes it difficult to confirm the value of potential benefits and means that scenarios have to be used. Likewise, while a part of some of the work of projects is awareness raising and training workshops, lack of data renders it is difficult to measure the success of those activities. Nevertheless, it is not the purpose of the projects to generate information for economic analysis. Having said this, such data would certainly allow the better provision of evidence of the value of the projects.

Of course, lack of baseline data to assess water adaptation projects is not new. GAR (2011) observes the critical lack of data in water management and its limitation to affect informed policies in climate change adaptation.

Chapter 10 Cost benefit analysis of the three selected projects

10.1 Project pay offs

Assuming a 10 per cent discount rate, that composting toilets are fully accepted by the community using them (100 per cent adoption), that the community experiences a reduction in water borne illnesses of 15.5 per cent pear year, that bottled water purchases fall by 3 per cent as a result of improved water supplies and that the benefits of the PACC and EU-B Envelope projects eventually start to tail off at 3 per cent year after 2019, the potential net present value of the three projects in Funafuti, Tuvalu could be as high as AU$ 2.7 million over 20 years, with a benefit: cost pay off of 1.8:1 – that is, a cost saving of almost AU$2 for every dollar invested (Table 17).

Table 17 Net present value of all projects

Total present value of benefits (potential gross benefits AU$)	Total present value of costs (gross costs AU$)	Net present values (AU$)	Benefit: cost ratio
2663989	1474391	1189598	1.81

The single highest contributor to benefits under this scenario is potential benefits from health, accounting for three quarters of benefits, compared to cost savings from water supply.

The estimates are not certain. The health benefits estimated for the projects may be overstated as not all existing symptoms related to water borne disease may have been caused by poor water. Where problems are due to other causes – such as poor hygiene – health benefits associated with the projects may be overestimated. On the other hand, the potential benefits of some, impacts the projects and are understated in many respects. For example, estimated project benefits do not include estimates of the value of water savings from a proposed PACC water cistern for the Lofeagai community, of values from improved coastal ecosystems and fishing opportunities, any reduction in chronic health problems and/or reduced stress. Some of these could be large. Critically, no estimate is made of the value of benefits associated with activities inspired by the projects. This is important since some of the projects are specifically intended to catalyse other projects and act as demonstrations of the value of specific activities.

10.2 Sensitivity analysis

The estimates were generated with limited data on actual changes that will occur in the future over the next 16 or so years. The estimates were therefore generated, using assumptions, and the values provided are highly sensitive to certain ones. The parameter most affecting the potential benefits of projects is the assumption of the extent to which incidence of water borne disease is reduced and the speed at which composting toilets are adopted.

As an example, the benefits presented in Table 17 assume that the projects would generate a reduction in the incidence of water borne disease by 15.5 per cent. If this was raised to 25

per cent, the net present value of the three projects might be expected to double to AU$ 2.4 million with a benefit: cost ratio of 2.6 (Table 18). By comparison, if the projects achieved a reduction in incidence of only 6 per cent, the net present value of the three projects might be expected to fall substantially and only just to about costs (Table 18).

Table 18 Net present value of all projects (varied impact on health)*

% Reduction in water borne disease	Total present value of benefits (potential gross benefits AU$)	Total present value of costs (gross costs AU$)	Net present values (AU$)	Benefit: cost ratio
6	1471423	1474391	-2968	1.00
15.5	2663989	1474391	1189598	1.81
25	3856555	1474391	2382165	2.62

* Values may vary slightly due to rounding.

By comparison, estimates are presently less sensitive to assumptions about the rate of adoption of composting toilets. If the community were reluctant to use the planned composting toilets planned for the IWRM and PACC projects and were only used 50 per cent of the time over the 20-year span examined, the expected net present value of the three projects might be expected to reduce only to AU$2.5 million with a benefit: cost ratio of 1.7, resulting (Table 19).

The probable reason for this low impact is that the planned composting toilets presently act as demonstration toilets and so are still extremely limited in number. It is possible – indeed intended – that the demonstration of the toilets will result in instigating greater demand for and use of such toilets in the future. The number of toilets to develop outside of these projects examined in the future has not been predicted so these potential 'leveraging' benefits have not been estimated.

Table 19 Net present value of all projects (50% composting toilet adoption)

Total present value of benefits (potential gross benefits AU$)	Total present value of costs (gross costs AU$)	Net present values (AU$)	Benefit: cost ratio
2525989	1474391	1051598	1.71

Ultimately, the number of potential combinations of assumptions for the projects is high, depending on whether one or several assumptions are varied at once. Therefore, to provide an indication of the likely impacts in Funafuti of different assumptions, six scenarios are presented below:

SCENARIO 1 worst case$_a$ No reduction in bottled water purchases are achieved over time; composting toilets used at only 50 per cent capacity for first 20 years due to initial community reluctance; projects achieve only a 6% reduction in illness, there is no increase in population size

SCENARIO 1 worst case$_B$ No reduction in bottled water purchases are achieved over time; composting toilets used at 100 per cent capacity for first

	20 years due to initial community reluctance; projects achieve only a 6% reduction in illness, there is no increase in population size
SCENARIO 2 medium case$_a$	no reduction in bottled water purchases are achieved over time; toilets used at only 50 per cent capacity for first 20 years due to initial community reluctance; projects achieve a 15.5% reduction in illness, no increase in population size
SCENARIO 3 medium case$_b$	3% reduction in bottled water purchases over time; composting toilets are used at 100 per cent capacity from day one; projects achieve a 15.5% reduction in illness, 0.005 increase in population size
SCENARIO 4 good case	3% reduction in bottled water purchases over time; composting toilets are used at only 50 per cent capacity for first 20 years due to initial community reluctance; projects achieve a 25% reduction in illness, 0.005 increase in population size
SCENARIO 5 best case	5% reduction in bottled water purchases over time; composting toilets used at 100 per cent capacity; projects achieve a 25% reduction in illness, 0.005 increase in population size

The combined potential benefits and payoffs from the projects under these varying conditions are presented in Table 20. It can be seen that the projects could be expected to generate positive payoffs under virtually all conditions. This would reflect Tuvalu's extremely difficult water security problems at present and underscore the critical need of the country to improve water security. The variability in pay offs reflects the sensitivity of project benefits to health impacts. As a result, it can be seen that payoffs are highest when it is assumed that the projects will substantially reduce the incidence of water borne disease while projects only scrape towards breaking even if health impacts are low.

Table 20 Potential project pay offs under different conditions

	Gross benefits AU$m	Gross costs	NPV AU$m	B/C ratio*
Scenario 1	1.3	1.47	-0.1	0.90
Scenario 1$_b$	1.4	1.47	0.0	1.00
Scenario 2	2.5	1.47	1.0	1.70
Scenario 3	2.7	1.47	1.2	1.81
Scenario 4	3.7	1.47	2.2	2.52
Scenario 5	3.9	1.47	2.4	2.62

* Values may vary slightly due to rounding.

The potential benefits of the projects are also sensitive to assumptions about the size of discount rate. High discount rates generally reduce the potential attractiveness of investments in to the environment. As an indication, under Scenario 3, potential project results more than double if a low discount rate of 3 per cent is used compared to a more standard rate of 10 per cent (Table 21). In all cases, the potential pay off for the projects is positive.

Table 21 Impact of discount rates on potential returns: Scenario 3

Discount rate %	NPV AU$m	B/C ratio
10	1.2	1.81
7	1.8	2.06
3	3.0	2.48

Given the limited data available to estimate the benefits of projects into the future, the values provided in this analysis must be treated as provisional.

10.3 Other issues

Technical sustainability of adaptation benefits

As indicated in section 10.3, the location of the PACC Lofeagai water cistern has been questioned by some stakeholders. In fact, the PACC project apparently considered the technical design of the water cistern to withstand impact of climate change and service the community in the near future. On the other hand, no documentation has been made available on the process used for its location (such as an environmental or engineering impact assessment). Given the perilous location of the village, enhanced information sharing on the rationale used to site the cistern would allay concerns of future risks to the cisterns that presently exist (Loia Tausi, PACC Coordinator, Government of Tuvalu, personal communication 2011).

In the interim, ensuring behaviour change supported by the projects in water use efficiency might be assisted if increased evidence of their contribution generated to health is provided. While this information does not presently exist (assumptions had to be made for this analysis), information from monitoring and assessment in the near future will then be critical. Revealing the health benefits more accurately might create incentives for ongoing community buy-in to the projects while complementing any support by Government of Tuvalu towards the work. Nevertheless, this commitment to ongoing work through the IWRM project – especially given that the work of the PACC and EU-B Envelope would receive no further support after completion – would be critical to sustainability of benefits.

Consultations conducted as part of this assessment in Tuvalu reveal that community and government representatives were adamant that water projects must continue to improve their training and education of children. Both the Tuvalu Association of Non-Governmental Organisations (TANGO) and the local town council the Kaupule claim that there is a need for more funding, whether from government or donor agencies, to focus more regular attention on water use efficiency, proper water treatment and sanitation practises in primary schools.

One of the suggestions from the Department of Education (Katalina Taloka, Director of Education, personal communication, 2011) was to build composting toilets at the schools on

Funafuti, to ensure that children learned how to use them and would support their families and communities in converting away from flush toilets. Primary school education issues were not considered in the design of all projects (although the GEF IWRM project did explicitly consider this) and there may be a need to revisit this as part of an overall strategy for climate change adaptation in the future.

10.4 Summary

The global link between diarrhoeal illnesses, unsafe water and rising global temperatures represents the role of climate change in causing costs such as these health problems involved with unsafe water. In Tuvalu, for example, technical studies such as this one can represent these global links at the national level, with the aims of improving climate change adaptation in those regards.

Assuming the success of the three water projects discussed in this assessment, social benefits from addressing water security should have high beneficial impacts through improved health and reduced need to access alternative sources of water. Limited but existing information would suggest that, if successful, the projects could generate social benefits on Funafuti in the order of $1.8 dollars saved to every dollar invested. According to personal communications, the provision of rainwater tanks, focus-group workshops and radio communication have been the most popularly used means of education for improved sanitation and water use efficiency across Funafuti. Additionally, Tuvaluan counterparts have identified the nascent success of the 20 composting toilets that have been built and implemented across Funafuti (Seleganiu and Moulogo 2010). Both the PACC and the GEF IWRM projects plan to construct more composting toilets over the project duration, following positive results from current demonstration projects such as the GEF IWRM. Therefore, the potential benefits to the local community could increase in the future.

Chapter 11 Framework for adaptation

As has been stressed throughout this document, the analysis conducted of the three water projects in Tuvalu to date is preliminary and, as already indicated, based on limited empirical information. Data problems existed due to lack of data as well as where data was available, inaccessable due to questions of privacy (for example with regards to the Meteorological Office's climate change data). The lack of data seriously impeded quantification of project impacts, with major assumptions consequently needed to describe the potential magnitude of projects effects. As a result, the values generated for this assessment must only be considered as indicative. The results underscore the critical need for the design and assessment of climate change adaptation projects to be supported by the most basic information.

To inform the development of sustainable adaptation projects in the water sector in the future, the following factors might be added into the design, priority given to linking project design to identified priorities and baseline data:

Project design

- improved use of ex-ante socio-economic assessment in determining project outcomes (in coordination with community engagement);
- establishing baseline data (appropriateness of site for construction purposes, collection of minimal baseline data for future monitoring purpose and provide an evidence base of project effectiveness); and
- clear coordination across projects – or stakeholder understanding of that coordination – to optimise project benefits through knowledge sharing, resource use and complementarity of actions.

Behaviour change

- support for behaviour change through relevant legislation;
- where suitable, the use of active awareness-raising, rather than passive awareness-raising;
- possible inclusion of sanitation awareness work in school curriculum (this is currently being conducted by GEF-IWRM but ulterior demands have been expressed by, for example, the Ministry of Education); and
- ongoing support from governments, following project completion.

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Luke Paeniu	Local Consultant for PACC
Dirend Prasad	Manager Rotumould
James Conway	Technical Assistant to National Authorising Officer
Tepa Lalau	Treasury
Ms Olioliga Iosua	Permanent Secretary (PWD)
Salesi Safega	Director Ministry of Finance and Economic Planning Customs Department
Sete Faiva	Senior Collector Customs
Uatea Maimoaga Salesa	Deputy Director of Public Works
Dr Nese Ituaso-Conway	
Annie Homasie	TANGO
Hilia Vavae	MET Office
Lofegai community	
Uluao Lauti	Kaupule Town Council
	Quantity Surveyor
Lofeagai Community	Tofega Falagi – Parish Minister of Lofeagai 5 women, including the Treasurer of Lofeagai, President of the women's group and the Secretary Pofity is a community member and manager of TANGO Satala was the elder deacon, elder leader
Kaevaa Lototele Roy	Health Statistician
Tepola Kani	HEO (Health Finance)
Natano Elisala	Pharmacist
Katalina Taloka	Director Education
	Director Public Health
Toligi Paueli and Tony Prcevich	
Susana Taupo	
Soseala Tinilau	National Ozone Office Department of Environment
Trinny Uluao	Labour Officer, Ministry of Foreign Affairs, Environment, Tourism, Trade and Labour
Sania Teisini	Director Inland Revenue
Letasi Iulai	Director Planning and Budget Ministry of Finance and Economic Development
	Secretary to the Government
Nakala Nia	NAPA Coordinator
Itaia Lausaveve	Director Agriculture
Kulene Sokotia	Land Minister
Florent Baarsch	Researcher

Annex 2 Activities undertaken

Deliverables	Due Date
Contract signed	February,
Key international and regional literature for review identified, key CROP agency stakeholders contacted for consultation identified and in principle support obtained	March, 2011
Key Tuvalu literature reviewed	March -April, 2011
Tuvalu field visit for consultations and data collection	End March- early April 2011
Preliminary analysis	April-August 2011
Draft report prepared	September 2011
Final report to IUCN	November 2011

Annex 3 Detailed description and budget of activities: GEF IWRM Project*

* Does not include activities co-funded through other projects such as the SPREP-executed PACC project

OUTPUT	Description	(USD)
1. National Policy/Legislation		
1.1 Consider revision of national legislation and policy	1.1.1 Identify gaps and opportunities	3,000
	1.1.2 Recommendation to amend legislation and policy	
	1.1.3 Monitor and support recommendations	
1.2 Review Draft Water Act and Water Policy	1.2.1 Identify gaps and opportunities	
	1.2.3 Draft Legislation and policy	
	1.2.3 Strategy to support progress to adoption (legislation/ policies through parliament)	
2. Sound Governance		
2.1 Reconvene Water and Sanitation Steering Committee	2.1.1 Revisit Terms of Reference and Roles and Responsibilities	
	2.1.2 Reconfirm members of Steering Committee	12,000
	2.1.3 Establish Executive support for Steering Committee	
2.2 Define water and sanitation roles and responsibilities	2.2.1 Identify options for improving government agency roles	
	2.2.2 Define Agency roles and responsibilities	
3. Plans and Strategies		
3.1 Undertake water and sanitation planning as required	3.1.1 Collect and collate existing information	2,000
	3.1.2 Develop a Draft Water and Sanitation Plan as required	
	3.1.3 Consult stakeholders on Draft Water and Sanitation Plan	1,000
	3.1.4 Water and Sanitation Plan	
3.2 Communication Strategy	3.2.1 Develop and implement communication strategy	15,000
	3.2.2 Complete IWP video and circulate	
	3.2.3 Use media to advertise consultation and invite participants	
	3.2.4 Information exchange with outer island communities (including visitations)	
3.3 Capacity Building Strategy	3.3.1 Capacity building needs assessment	5,000
	3.3.2 Develop capacity building strategy	

	3.3.3 Implement Capacity Building strategy (seek donor funds where necessary)	
	3.3.4 Awareness and training sessions on common toilet systems (consider micro business)	5,000
3.4 Participation Strategy	3.4.1 Develop participation strategy	
	3.4.2 Implement participation strategy	5,000
3.5 Replication Strategy	3.5.1 Develop replication strategy	
	3.5.2 Transfer of best practices to rest of Tuvalu and beyond	500
4. Review Information and Data		
4.1 Obtain further information	4.1.1 Maintain continuous and up to date information	
4.2 Assess current status of Funafuti sanitation and wastewater impacts	4.2.1 Update sanitary system statistics	6,000
	4.2.2 Update health statistics on waterborne diseases	
	4.2.3 Review available water quality information for Fongafale lagoon	
	4.2.4 Conduct surveys of attitudes/perceptions	
	4.2.5 Assessment of groundwater resources	
4.3 Revisit cost benefit report	4.3.1 Design dry sanitation system	13,000
	4.3.2. Invite volunteer households to trial systems	500
	4.3.3 Construct minimum of 40 composting toilets	160,000
	4.3.4 Evaluate project and refine designs	2,000
	4.3.5 Develop costed strategy to replicate preferred option	
	4.3.6 Identify funding mechanisms for preferred option	
	4.3.7 Monitor trial sanitation systems/community response	500
	4.3.8 Report on study	
4.4 Improved septic systems study	4.4.1 Review sludge handling and disposal/ treatment options	2,000
	4.4.2 Review the suitability of the existing septage treatment site	
	4.4.3 Replace/repair septic systems/ other systems at volunteer households	40,000
	4.4.4 Costed design of preferred sludge treatment option	3,000
	4.4.5 Identify funding mechanism or source	
	4.4.6 Monitor trial sanitation systems/community response	500

5. Develop tools for management		
5.1 Revise Building Code to incorporate guidelines on water and sanitation.	5.1.1 Present a submission to cabinet, supported by PWD, to gain support for revising the building code legislation.	
	5.1.2 Produce regulations for inclusion into a revised National Building Code	1,000
	5.1.3 Follow strategy to support progress to adoption	
5.2 Support development of rainwater storage model	5.2.1 Support development of rainwater resource model (PACC)	
	5.2.2 Resource and implement monitoring programme (PACC)	
6. Support for ground works		
6.1 Support improvement of rainwater infrastructure	6.1.1 Support installation of guttering and rainwater tanks (current EDF9/AusAID)	

Annex 4 Detailed description and budgeting of activities: EU B-Envelope project

(Euros)	2008	2009	2010
Component 1 - RWH Tanks Funafuti			
Training Workshops	5,500	0	0
Funafuti Household Tanks	326,133	23,867	0
Community Tanks	15,000	0	0
Component 2 - Tank Installation			
Labour & Project Management	11,000	11,400	0
Tank Fittings	12,600	0	0
Excavation, Site Preparation	3,000	3,300	0
Transport Delivery	1,200	2,000	0
Gutter, Fascia, Brackets	20,000	12,758	9,242
Component 3 - Road Tanker Refurbishment & Replacement			
Equipment	0	30,000	277
Component 4 - Eco-Sanitation Programme			
Personnel	0	1,000	0
Equipment	0	500	0
Training	0	500	0
Travel & Per Diem	0	300	0
Materials	0	0	0
PMU	6,808	10,837	15,730
Travel & Visibility	983	2,465	24
Evaluations	0	0	0
Audits	169	174	204

Annex 5 PACC project expenditure

Outcome 1: Policy changes to deliver immediate vulnerability- reduction benefits in context of emerging climate risks defined in Tuvalu (USD)	2011	2012	2013
Output 1.1 Water sector policy revised to incorporate climate change risk and resilience aspects			
Activity 1.1.1 Review the draft water policy developed under IWP funding	2,000		
Activity 1.1.2 Analysis of climate change gaps and related institutional capacities support	4,000	10,500	8,000
Activity 1.1.3 Consultations/training on integration of CC information into water policy	2,000		
Activity 1.1.4 Draft the revised national water policy	5,000		
Activity 1.1.6 Review the national water policy. Application of the modified policy framework and instruments in pilot demonstration (where appropriate) and integration of demo and pilot experience informing the water policy framework			
Activity 1.1.7 – High level official approval, process of revised water policy and its related instruments (Cabinet endorsement)	3,200		
Output 1.2 National Climate Change Policy developed			
Activity 1.2.1 Conduct stocktaking and develop an overview of national and sectoral policies, strategies, plans and related instruments	2,500		
Activity 1.2.2 Analysis of climate change gaps in policy frameworks and in related institutional capacities: desk review and consultations	2,500	10,500	8,000
Activity 1.2.3 Establish plans and timelines for mainstreaming process, agreeing on mainstreaming objectives and policy instruments to be modified or developed	850		
Activity 1.2.4 Consultations on reviews required for developing the National Climate Change Policy	2,000		
Activity 1.2.5 Modification of policy instruments for CC integration and development of new CC policy	1,200		
Activity 1.2.6 Develop National Climate Change Policy	10,000		
Activity 1.2.7 Official approval, process of revised or new policies (e.g. Cabinet endorsement)			
Outcome 2: Demonstration measures to reduce vulnerability in water sector implemented			
Output 2.1 Guidelines developed to integrate climate risk into the water sector and demonstration activities			
Activity 2.1.1 Undertake water quality; GIS-mapping of water quantity; water demand management; underground water assessment; supply & distribution; vulnerability & adaptation; socioeconomic; and CBA assessments of Lofeagai and Vaiaku pilot sites	22,500	22,500	

Activity 2.1.2 Identify adaptation options	3000		
Activity 2.1.3 Evaluate and select adaptation measures through cost benefit or cost effectiveness analysis	3,000		
Activity 2.1.5 Prepare draft guideline by documenting and analyzing the adaptation assessment, planning processes, and lessons learnt from the pilot site	15,000		
Activity 2.1.6 Conduct training workshops on the guidelines to be applied in a pilot demonstration situation (aligned closely with activities in Output 3.2)	3,000	7,500	46,000
Output 2.2 Measures identified in the Guide demonstrated [Implementation and monitoring of results]			
Activity 2.2.1 Carry out detailed design of adaptation measures	1000		
Activity 2.2.2 – Establish implementation plan	1000		
Activity 2.2.3 – Implementation of the adaptation measures at the pilot sites	180,000	50,300	25,500
Activity 2.2.4 – Evaluation and monitoring of pilot adaptation measures	3,000	32,000	6,000
Activity 2.2.5 – Review of the sectoral guidelines through integrating the experience from the demonstration and implementation activities [last two quarters of the project]			15,635
Outcome 3: Capacity to plan for and respond to changes in climate-related risks improved			
Output 3.1 National Communication and awareness plans developed and implemented			
Activity 3.1.1 Develop a national PACC communication strategy			
Activity 3.1.2 Develop country-specific education and communication materials	2,000	10,000	1,500
Activity 3.1.3 Organizing forums for senior policy and decision-makers, prepare cabinet briefing papers to inform on PACC activities/results	1,000	1,500	500
Activity 3.1.4 Prepare country-specific quarterly PACC newsletters/snapshots (distributed in print or through web, emails)	2,000	1,500	1,000
Activity 3.1.5 Organizing PACC activities connected to national events	2,000	1,500	500
Activity 3.1.6 Organize other types of communication and awareness activities as defined in national communication plans (see notes).	4,000	1,500	1,500
Output 3.2 Best practices and lessons exchanged among countries			
Activity 3.2.1 Document and share results of the project	2,000	1,600	500
Activity 3.2.2 Collect, document and share examples of best practices and lessons learnt in the following areas: community consultation, V&A assessments, adaptation planning and interventions demonstrated, mainstreaming climate change (national, sectoral and community)	2,000		
Activity 3.2.3 Exchange experiences, knowledge and lessons			

learnt through visits among countries for PACC Country Coordinators, policy makers and project participants			
Activity 3.2.4 Develop case studies and thematic reports on mainstreaming, sectoral applications and other technical aspects	3,350	1600	1000
Outcome 4: Project Management			
Output 4.1 National Project Management Units established and operational			
Activity 4.1.1 Sign MoU between SPREP & countries			
Activity 4.1.2 Contractual Services - Individual (NPC Salary)	25,000	12500	9000
Activity 4.1.3 Establish office and improvement of premises	2,000		
Activity 4.1.4 Develop and revise Annual Work Plan and update Multi-Year Work Plan accordingly	1,000	1000	1000
Activity 4.1.5 Prepare narrative and financial information and transactions for every quarter and forecast project expenditure for the next quarter			
Activity 4.1.6 Carry out Inception Meeting at the national level			
Activity 4.1.7 Assistance to technical core teams (TIGs, etc)	4,000	5,000	3,500

Annex 6 Data collection targets for Tuvalu

Data	Source	Questions
Costs of IWRM, EU-B Envelope and PACC	Project documents (email managers)	Costs – variable, fixed, timing for installation and re-installation Distribution of costs. Which factors are not included in the PACC/ EU B-Envelope/ GEF IWRM implementation costing? How frequently will major equipment have to be replaced?
Rights to **ownership of water**, land and local products (land protection laws? Where to build rainwater tanks.)	Right to Lands Dir Lands	Who has rights? How are they acquired? What are the implications for water lens/water equipment? What is the scope of changing ownership rights (should this be necessary)?
Current cost and quality of **infrastructure** management on Funafuti	Dir PWD	How many roads are there? How many pipes are there? Does the government fund any maintenance of IWRM equipment or is this all done through project funding? What kind of infrastructure damage is most prevalent and what are the causes?
Detailed information on **water quality** and quantity (rainfall volume)	Rodney Lui/ SOPAC/SPC base on the last survey he did here in Tuvalu/ Dir MET	
Scenarios on likely impacts on water quantity and quality on Funafuti if the projects successful and **Perceptions** of environmental protection and improved environmental services following success of the projects	Dir MET, Dir Environment, Dir PWD, NAPA coordinator	Expected population change over time Life span of each project What would have happened if the project had not been funded – did the government have other plans for improving water management? Expected change in water demand over time. Expected change in fuel price over time.
Interview **community** representatives to gauge water perceptions	Community members	
Number of **gastrointestinal** diseases (water borne/ water related) arising on Funafuti as a result of	Dir for Public Health	How many cases per year What illnesses most common How long to recover % caused by bad water versus other causes (poor sanitation/hygiene)

infected water supplies (i.e. lack of reliance on projects)		
Medical costs of treating gastrointestinal disease on Funafuti, including costs of hospital visits, medicine, average time off work and productivity losses	Dir P/Health, Pharmacist	Cost of treatment Who pays and how
Minimum wage rates in Tuvalu and average working age range	Dept Finance	What is minimum working age by law and in practise in Funafuti What is the per centage of people working Prominence of informal market
Demand for **alternative water** supplies (imported/domestic bottled water purchases, real costs of desalinated water production and use)	Dir PWD, Disaster coordinator	Amount of water bottles imported annually Price per bottle Bottle volume Is this a relevant issue in Tuvalu or is bottled water not affordable?
Number of **water filters/rainwater tanks** used by households, businesses, cost of purchase, installation, and maintenance (if not done via project) and other **water supply** issues	Dir PWD and Rotamould Supervisor	Total water use Total water supply Leakages and why Current use of desalination plant and maintenance costs.
Number of **water tanks bought by households** and businesses, cost of purchase, installation, and maintenance (if not done via project)	Dir PWD	Population of Funafuti Commerce (amount and type) and agriculture Destination of water harvested (Funafuti or elsewhere) Number of users elsewhere Other non-Funafuti users – industry, government, tourism. What is the water use for – drinking, washing, other (implications for final goal)
Current **farm** animal sanitation and potential improvements following projects (if in project remit)	Dept Agriculture	Type of problems with current management, if any (weaknesses and needs) Methods to improve sanitation and costs Number of farms Where are farmers from and are they aware of water issues?

Education improvements		Are there government initiatives in water management education other than IWRM? What are the different types of education methods? How much do they cost? Sustainable?
Fuel tariff	Ministry of Finance	How much is the fuel tariff? Where is fuel imported from?
Project design and **community** consultation	Communities	Water tanks What has the project done for your village? Has the project made any improvements and how? Any suggestion for improvement in water tanks? Were communities adequately consulted to identify and design the project and if so, how? Was climate change a significant consideration? Did community identify project objectives as required? Who was involved in project design, who was not, and what was the process? Water efficiency/changed use Views of compost toilets? Would individuals use them? Is there a culture of vandalism towards new property? Suggested improvements to reduce leakage and misuse? Do communities use water differently now?
Baseline data		What was the volume of usage before projects and now? What was the quality of water before projects and now? Spreadsheets please.

Annex 7 Data used for cost benefit analysis

Water security : Improved rainwater harvest, storage and management	
Examples of Information Used	Source of Data/ Information
Threats to water quality	Government records Department of Environment/ NGO consultations Published research
Household water storage capacity and costs: water catchment, gutters and tank maintenance of water catchment, storage structures	National census report Government agencies (Public Works Department) Published and grey literature, including from other projects Consultations with key stakeholders
Current use and trend in household water demand: Water consumption pattern Population trend and trend in water demand Volume and cost of alternative sources of water: imported bottled water desalinated water	National census reports Government agencies Published and grey literature, including from other projects(e.g. HYCOS, IWRM) Consultations with key stakeholders
Relationship between water supply and human health conditions (water borne disease)	Government agencies Published literature
Household water borne disease incidence and status	Government health records Hospital consultations Published and grey literature, including from other projects
Costs of treating water borne disease	Government Local hospital consultations
Costs improving water supply compared with the current status	Project documentation Consultations with key stakeholders Economics analysis