Sustainable Integrated Water Resources and Wastewater Management in Pacific Island Countries

National Integrated Water Resource Management Diagnostic Report

Tonga

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GLOBAL ENVIRONMENT FACILITY

UNDP

SOPAC

UNEP

ACRONYMS

ADB	Asian Development Bank
AusAID	Australian Government Aid Agency
CBD	Convention on Biological Diversity
CBO	Community Based Organisation
CPD	Central Planning Department
CT	Composting toilet
GPA	Global Programme of Action for the Protection of Marine Environment form Land Based Activities
HYCOS	Hydrological Cycle Observing System
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
MAFF	Ministry of Agriculture Forestry and Fisheries
MLSNRE	Ministry of Lands Survey Natural Resources and Environment
MOF	Ministry of Finance
MOH	Ministry of Health
MOW	Ministry of Works
NBSAP	The National Biodiversity Conservation Strategy
NEMC	National Emergency Management Committee
NEMO	National Disaster Management Office
NGO	Non Government Organisation
NZAID	New Zealand Government Aid Agency
PACC	Pacific Adaptation to Climate Change
PUMD	Planning and Urban Management Division
RWH	Rainwater Harvesting
SIDS	Small Island Developing States
SOPAC	South Pacific Applied Geoscience Commission
SPCZ	South Pacific Convergence Zone
SPREP	South Pacific Regional Environment Programme
SWMP	Solid Waste Management Project
TEPB	Tonga Electric Power Board
TMS	Tonga Meteorological Service
TVB	Tonga Visitor's Bureau
TWB	Tonga Water Board
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

WDM	Water Demand Management
WHO	World Health Organization
WMA	Waste Management Authority
WQM	Water Quality Monitoring
WSP	Water Safety Planning

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EXECUTIVE SUMMARY

The structure of this diagnostic report follows the outline of the Pacific Regional Action Plan on sustainable Water Management (Pacific RAP) arranged over six thematic areas of water resources management, island vulnerability, awareness, technology, institutional arrangements and financing, preceded by a general chapter on relevant background information on Tonga.

General Overview

The Kingdom of Tonga is a Small Island Developing state (SID) located in the Central South Pacific. It lies between 15º and 23º 30' South and 173º and 177º West. Tonga has a combined land and sea area of 720,000 km². It is an archipelago of 172 named islands with an area of 747 km². There are 36 islands which are inhabited, with an area of 670 kmº. Tonga had a total population of 97,784 at the Census of 1996, and an estimated population of 114,600 in July 2006, an increase of 46, 900 people over the decade. A decennial census was conducted in 2006, but the results had not been officially released at the time of writing (March 2007).

Within Tonga there is a western line of islands of volcanic origin, steep topography and generally high elevations, and an eastern line of generally low-lying limestone and mixed geology islands. Tonga's archipelago lies along the boundary of the Pacific and Indian-Australian tectonic plates. It comprises both volcanic and uplifted coral islands and reefs, which cap the peaks of two parallel submarine ridges stretching south of Fiji.

The climate of Tonga is semi-tropical. Tonga lies within the south-east trade wind zone of the South Pacific and its climate is dominated by south-easterly trade winds. Rainfall is moderate and variable, defined by two seasons, the Wet and Dry seasons. Two predominant causes of rainfall variation in Tonga are ENSO (El Nino-Southern Oscillation) and tropical cyclones. ENSO events can cause prolonged drought whereas tropical cyclones can result in unusually wet years. Data reflects a general decrease in annual rainfall in central and southern parts of Tonga particularly since 1970. Tropical cyclones and earthquakes occur in Tonga and can cause significant damage**.** Tonga's volcanic activity has been recorded since 1839, and includes submarine eruptions, and emerging and disappearing islands. In terms of impact on human settlement, there is an active volcano on the island of Niuafo'ou.

The freshwater resources of the Kingdom of Tonga consist mainly of groundwater in the form of freshwater lenses. Surface water resources are only evident on some of the high volcanic and mixed geology islands in the form of springs and lakes. Surface water is collected from cave systems on the island of 'Eua and used for potable water supply. Rainwater harvesting systems are a complementary freshwater resource, and an essential source of potable water on many of the islands. On some of the smaller islands in the Ha'apai and Vava'u groups they are the only source of freshwater.

Most of the islands of Tonga have a soil layer overlying coral limestone. The soils are mainly derived from andesitic tephra (volcanic ash). Other soils include coral sands and lagoonal sands and mud. There is a wide diversity of vegetation types throughout the islands of the Kingdom of Tonga. Indigenous vegetation includes a variety of rootcrops, fruit trees, and native vegetables and grasses. A significant percentage of the country is now under coconut in Panicum grassland.

Agricultural production is the most productive activity in the economy of Tonga and continues to dominate the value-added contribution to GDP. Rich volcanic soils on most of the islands provide a fertile base for production. Generally agriculture is rainfall dependent, and therefore highly vulnerable to the impact of drought. The agricultural sector is a source of domestic food supply, employment, cash income, foreign exchange earnings, and raw materials for processing and handicrafts.

The sea and its coastal resources have sustained Tongans since the inhabitation of the islands. The ocean and its resources as well as the coastal areas (from 50 feet above high tide watermark) are Crown/Government property and the rights to all resources (sand, dead coral,

marine life) are vested in the Crown (Constitution of Tonga and The Continental Shelf Act, 1970). However, in contrast to land access, there is a long-standing tradition of open access to marine resources.

Tonga's economy, as a small island developing state was typically structured around a large public sector with dependence on remittances, and foreign aid. In 1996, full-time government workers accounted for 39% of the 13,318 Tonga employees who are paid in cash. Downsizing of the public sector to increase efficiency has also been a policy supported by various donor agencies. In mid 2006, 1000 public servants accepted an offer of redundancy packages. Political unrest and the riots of November 2006 has impacted on the economy.

Issues and measures related to Integrated Water Resources Management for Tonga

The source of freshwater for Tonga is either through rainwater harvesting, or extracted from a thin freshwater lens within the highly porous limestone substrate. Groundwater is used domestically for cooking, bathing, washing food, watering plants and animals, flushing toilets, cleaning the house and vehicles. It is also boiled and used for drinking if rainwater is not available. It is piped to homes, government buildings, shops, industries and tourist accommodation by the Tonga Water Board (TWB) in the urban centres of Nukualofa on Tongatapu, Neiafu on Va'vau and Pangai-Hihifo on Ha'apai and to villages on 'Eua. Many villages outside these centres have their own reticulated water system administered by water committees. The Tonga Water Board supply is metered at each property. Some villages are now introducing individual meters.

It is not possible to generalise as each island within each island Group has varying water resource issues and concerns depending on population pressures, demand, quality and quantity of water supply, local geology, agricultural and sanitation practices, and standard of extraction.

Use of water for agricultural purposes is not recorded. Water drawn from village water supply systems is not metered. It is not known exactly how many bores are operating on Tongatapu, or in the other island Groups and it is not known what volume is being extracted. Bores can requested for private home, schools, churches, or village water supply.

There is no centralised reticulated sewerage system in Tonga. All wastewater is managed by on-site systems, with supervision by the Ministry of Health (MOH) when resources permit. In this respect wastewater management is in the hands of the community. Poorly constructed or inappropriate sanitation systems are common, resulting in the potential for pathogens and nutrients being introduced into the surrounding environment, including ingress to groundwater. Excess nutrient loads appear to be impacting the environmental health of the near shore reef in the Nuku'alofa area, and the lagoon in general. Algal growth can be seen in both areas. In addition, there are concerns that fish harvested in these areas, particularly shellfish, may be contaminated. Waterborne disease is common. A concern with the current sanitation practice is the potential for contamination of the aquifers designated for TWB and village reticulated supply. This can be exacerbated by over-pumping.

There is also a threat of contamination to private hand operated wells especially in the outer islands. Efforts by MOH to close these private wells because of this threat is very much resisted as the wells are a traditional and valued source of free, fresh water.

Dry sanitation options (non-waterborne, zero discharge treatment) such as composting toilets (CTs) have been introduced in Tonga over the last decade. Introducing new toilet technology is a challenge in any culture and requires long term comprehensive attention to complex socio-cultural factors. Over the years, there have been recommendations for a reticulated sewerage system in Nuku'alofa and other urban areas throughout Tonga. However the cost and complexity of this is currently prohibitive, and it may cause as many health and environmental threats.

There is no there is no functioning information or data exchange systems on water resources or 'National Hydrological Network' for water resources assessment and monitoring. Water resources are currently managed by a number of institutions, some of which have specific or

general monitoring. There is a need for a collaborative approach to management including integrated planning, the introduction of buffer zones, demand management strategies, and comprehensive education to demonstrate the links between poor sanitation and waterborne disease and environmental degradation.

Disasters or emergencies which could affect water resources in Tonga include chemical pollution from pesticides, fertilisers, oil and industrial chemicals, biological pollution, extreme weather events such as cyclones, earthquakes, drought and flooding. Overtopping by waves or inundation by high sea levels has caused seawater intrusion into freshwater lenses hence reducing the availability of potable freshwater. Beach mining for sand and aggregate (dead coral) have also increased the impact of storm surges on coastal areas. Inundation has affected town and tax allotments, resulting in the abandonment of houses, and crops. There are significant health and economic impacts from these emergencies.

A National Emergency Management Plan has been developed which builds on the 1987 national disaster plan, and a National Emergency Management Committee has been formed (NEMC) and a National Disaster Management Office (NEMO) has been established within the Ministry of Works (MOW). The Emergency Management Act (2006) is currently before Cabinet.

Demand management measures, augmenting water supply, drought vulnerability assessment and climate forecasting can all help toward disaster preparedness. Institutional and regulatory support is required to effectively prepare for and manage disasters, and to reduce the impact of climate variability on freshwater resources. Bills and Acts have been developed which support a sustainable approach. They require approval, and funding allocated for implementation.

Wastewater management is almost entirely in the hands of the householder as all sanitation treatment in Tonga is on-site. In regard to water management, most households have a rainwater tank, and some have their own well. Management of reticulated water is also dependent on the behaviour and attitude of the consumer. Education is conducted through public meetings, school presentations, TV programmes, theatre, and radio broadcasts. However it is also necessary to actively engage householders and the wider community, and provide them with practical tools to sustain their resources. There is a need to re-connect with traditional values regarding protection of resources.

The village water supply committees require financial and technical assistance and-on the-job training to establish and maintain their systems. There are many instances of poor maintenance which could impact on quality. Extraction rates or quantities are not controlled.

Low income families require financial assistance to establish and maintain rainwater harvesting systems. All householders can benefit from technical training in system construction and maintenance. Institutions such a MOH and the Hydrology Unit require technical and financial assistance to adequately monitor biological and chemical pollution of water resources, and rates of extraction.

Unlike the electric energy utility, the TWB is not subsidised, but it manages to cover its running costs, and contribute to consolidated revenue. Sources of revenue are water sales, contracts for services such as upgrading village water supply, training village water committees, and selling plumbing and fittings. Village water supply systems are installed or upgraded through grants from donor agencies and running costs are partly covered by minimal meter charges. Rainwater harvesting systems are funded by small grants from donor agencies administered through NGOs. Revolving loans and fundraising is organised within women's groups. There is insufficient funding for water conservation and demand management activities, and a lack of financial support to water resources managers.

There is no comprehensive law in Tonga dealing with issues of ownership, management and protection of water resources. This is despite the fact that the need for such legislation has been clearly highlighted in various documents, national consultations and conferences since 1991. Provision is made in relation to pollution of water in a number of laws and these laws involve a range of government agencies.

In the absence of appropriate institutional arrangements, there are many issues of concern such as no control over extraction rates, minimal supervision of pollution of groundwater from pesticides, fertilisers and inappropriate sanitation systems, no urban control mechanisms based upon the availability of water supplies and possible adverse effects on the groundwater.

A Water Resources Bill is before Cabinet and its implementation will address these and other concerns. The Water Resources Act will give a wide range of powers to the Minister of Lands, Survey Natural Resources and Environment to manage, protect and conserve the water resource. To support implementation of the Water Resources Act when it is passed the following capacity building will be required. 

Linkages to landuse, agriculture, watershed and coastal management, public health

There is no specific landuse policy which has special emphasis on management of water resources. Tonga has a complex traditional land tenure system which needs to be taken into account when land/water use is considered. There are a wide range of water resources management issues which are related to land tenure and use, such as control of extraction rates, sanitation and solid waste disposal practices, the use of agrichemicals, and deforestation. As previously discussed all these factors have the potential to affect public health and impact on terrestrial and marine ecosystems. There is a direct connection between watershed and coastal management, and there is a need to integrate technical and social science to demonstrate the links and facilitate management.

Stakeholder engagement

To undertake this diagnostic report information was gathered initially from reports, and updates for current conditions was collected from email and telephone correspondence and a week's field trip to Tongatapu in February 2007 which included discussions with personnel from relevant ministries, non-government organisations, and community members, and personal observations. At each interview conducted in Tonga the IWRM project was explained, and the relevance and opportunity for personnel to participate in ongoing activities was discussed. This included being a member of the National Water Resources Committee, contributing to the Hot Spot Analysis (HSA), and development of the Demonstration Project.

Other programmes, projects and activities related to IWRM

There are a significant number of current and proposed regional and bi-lateral programmes which potentially relate to sustainable integrated water resources management in Pacific Island countries. Efforts are being made by some executing agencies to ensure that programmes are complementary and enhance effective implementation and that duplication or conflicting agendas do not occur.

Capacity development needs for removing barriers

Some of the agencies responsible for water resources management are understaffed, particularly the Natural Resources Unit of the Ministry of Lands Survey Natural Resources and Environment (MLSNRE). Dedicated facilities and additional staff are required for biological water quality analysis at the MOH. Newly recruited and existing staff require training.

Collection of water samples and testing for biological and chemical quality (including agrichemicals) needs to be centralised, with necessary facilities, equipment, and reagents secured. Village water committees require training in maintenance and monitoring of water supply systems.

Householders need training in the design, construction and maintenance of rainwater harvesting systems, sanitations systems and private wells.

Water managers have expressed a preference for specially designed in-country courses, and on-the-job training. It has been observed that regional training often does not address the specific needs which exist in Tonga, in terms of level of expertise, available equipment, local hydrology/hydrogeology and geographic and socio-cultural conditions.

Farmers need training in the safe use of pesticides and fertilisers, and organic farming techniques based on traditional local gardening practices, including niche marketing.

A National Water Resources Committee will require support for establishment and ongoing communication. The committee and its associated members require training in integrated planning, policy and legislation review, community engagement skills, and promotion of public awareness.

There is a need for capacity building in drought planning, water demand management, cost recovery, improved fuel and pesticide management, and ecological surveying for all relevant agencies and operators.

Introducing an integrated approach toward barrier removal

The emphasis should be to build on existing skills and relationships, to facilitate cooperation and sharing of resources and information, and to nurture traditional and cultural values and knowledge of resource management.

Comprehensive water resources legislation in the form of the Water Resources Bill which is before Cabinet should be enacted in the near future. All steps should be taken to facilitate this process. The new Water Resources Act should then be implemented, providing for effective planning, assessment, development, control, monitoring and protection of water resources throughout the Kingdom of Tonga.

The Water Resources Act will provide a mandate for the Ministry of Lands, Survey Natural Resources and Environment (MLSNRE) to control and monitor the water resources of Tonga. It will administer the provisions of the Act and coordinate other agencies in supporting roles, providing an opportunity for integrated planning and ongoing adaptive development of a national water policy and strategy.

While regulations and guidelines will be necessary, a partnership approach should be developed with the community to ensure compliance. This includes all water users, and landholders who are providing access to groundwater. A National Water Resources Committee will be established to keep all stakeholders involved and informed, and to assess training and capacity building requirements.

The water resources monitoring programme conducted by the Hydrogeology/hydrology Unit of the Ministry of Lands, Survey and Natural Resources should be practically strengthened to become an effective national monitoring programme with supplementary information provided by the Tonga Water Board, Ministry of Health Village Water Committees, and NGOs and community based organisations (CBOs) involved with rainwater harvesting programmes.

Permanent monitoring systems to obtain vertical salinity profiles should be installed in the freshwater lenses on Tongatapu, Lifuka in the Ha'apai Group and Vava'u so that they can be monitored at regular intervals. Installation costs associated with drilling should be funded, where necessary, by an external funding agency.

All existing bores, both government and private, should be assessed and location, purpose and estimated usage recorded. Pump sizes and extraction rates should be controlled.

The groundwater resources database at the Hydrogeology Unit should be maintained to include all current water resources information including surface water flows, rainfall and climatic data, and biological and chemical water quality, and analysis and modelling systems should be regularly updated. The data base should be available to other agencies, and relevant stakeholders.

An additional staff member should be allocated to the Hydrogeology Unit to assist with the collection processing, archiving and analysis of hydrological and hydrogeological data, and on-the-job training should be provided to relevant staff.

Householders should be provided training in the design construction and maintenance of a range of on-site sanitation systems, particularly septic tanks and composting toilets. Training should include the advantages and disadvantages of the various systems including graphically

demonstrated environmental and health impacts of the treatment/disposal process. Householders should be trained in the design construction and maintenance of rainwater harvesting systems. NGOs which have assisted with revolving loans and other fundraising activities should be engaged to offer further support. Householders should be trained in the design construction and hygienic maintenance of private wells, in communities where these are still used, and traditional pride in the family well recognised and encouraged. Where possible training should equip the trainees to a standard where they could be contracted to assist other householders to construct and maintain their water supply and sanitation systems.

Farmers should be trained in organic farming techniques based on traditional local farming practices and introduced to niche organic markets in developed countries. A model farm could be established to demonstrate irrigation by rainwater harvesting, use of organic pest control and fertilisers (including pig manure and compost), ecological sanitation including management of livestock, especially pigs, and sustainable rain water and groundwater management.

Tourism in Tonga should be further marketed as a ‘clean green experience’ to encourage and support an integrated approach to the management of water and all other natural resources.

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Thanks to all the people in Tonga who generously shared reports and information, especially personnel from the Solid Waste Management Project at Ministry of Works, the International Waters Programme and Natural Resources section at MLSNRE, Ministry of Agriculture Forestry and Fisheries, the Ministry of Health, the Tonga Water Board, Tonga Meteorological Services the Central Planning Department the National Emergency Management Office, AusAID, NZAID and JICA. Thanks also to staff at SOPAC for providing publications and guidance.

INTRODUCTION

The Sustainable Integrated Water Resources and Wastewater Management Project in Pacific Island Countries has evolved from and responds to the Strategic Action Programme (SAP) for the International Waters of the Pacific Small Island Developing States. The priority transboundary concerns for Pacific Island International Waters were defined as arising from the following imminent threats to the health of those waters:

1. pollution of marine and freshwater (including groundwater) from land based activities
2. physical, ecological and hydrological modification of critical habitats
3. unsustainable exploitation of living and nonliving resources

and the ultimate root causes to lie within management deficiencies, particularly those related to lack of governance, and lack of information and understanding (knowledge deficiencies). The SAP identifies the solutions to these threats and root causes to be;

A. Integrated Coastal and Watershed Management and

B. Oceanic Fisheries Management (which will be addressed in a separate Global Environment Fund project)

In addition the project supports the Pacific SIDS in the Pacific Regional Action Plan (RAP) that addresses sustainable water management. The Pacific RAP on sustainable water management aims to improve the assessment and monitoring of water resources, reduce water pollution, improve access to technologies, strengthen institutional arrangements and leverage additional financial resources in support of IWRM. It is structured around six themes which contain key messages to stakeholders on:

1. Water resources management
2. Island vulnerability
3. Awareness
4. Technology
5. Institutional arrangements
6. Finance

All countries could benefit from an integrated approach to water resources management but the Pacific SIDS have an urgent need to adopt this strategy due to small land mass, fragile ecology, limited financial technical and human resources, and the vulnerability to natural disasters and extreme weather events. In the past water supply and sanitation services and programmes have not been devised in an integrated way that takes into account all the inputs and output of a system. For example the positive benefit of providing a reticulated water supply may be outweighed by the health hazards and poor living conditions which could result from not considering the appropriate disposal of used water which may create standing water or pollution of receiving waters. Source control and more efficient use and re-use of water are the most effective ways to reduce demand for treatment and disposal. While an integrated approach to the management of natural resources existed in traditional societies, population growth and rapid development and introduction of ‘modern’ technologies and practices over the last 50 years has not allowed enough time and perspective to adjust and plan holistically. Now that the damage is clearly apparent there is an attempt to reverse the environmental degradation and threat to public health and security, by addressing all inter-connected elements of the system.

1. GENERAL OVERVIEW

This section of the report draws on previous studies, reviews and consultations conducted in Tonga, over the last 15 years, as indicated by the references. Substantial background information has been extracted from a number of national reviews conducted by local consultants and members of the public service, namely the “Initial National Communication under the UNFCCC” (Tui’i’afitu 2005) funded by GEF/UNDP, which follows similar guidelines as this diagnostic report, and is in part a compilation of previous studies; and the Tonga Country Report developed from a national consultation in 2002 in preparation for development of the Regional Action Plan, which was submitted to Third World Water Forum in Japan in 2003.

The time allowed for the current study is insufficient for material to be originally sourced. Other sources are listed in the references.

Updates for current conditions are provided from email and telephone correspondence and a week’s field trip to Tongatapu in February 2007 which included discussions with personnel from relevant ministries, non-government organisations, and community members, and personal observations. Access to institutions and information was limited because of the shortage of staff that has occurred since the public service was reduced by 1000 people in mid 2006. In some cases data and information that these people were responsible for is misplaced or difficult to find. The government personnel who have taken their place now have additional responsibilities, and are currently in the process of adjusting to new and multiple roles, and in some cases within recently amalgamated or relocated divisions.

1.1 Location, topography and Island Groups

The Kingdom of Tonga is a Small Island Developing state located in the central South Pacific. It lies between 15º and 23º 30' South and 173º and 177º West. Tonga has a combined land and sea area of 720,000 km². It is an archipelago of 172 named islands with an area of 747 km². There are 36 islands which are inhabited, with an area of 670 km². Tonga had a total population of 97,784 at the Census of 1996, and an estimated population of 114,600 in July 2006, an increase of 46, 900 people over the decade. A decennial census was conducted in 2006, but the results had not been officially released at the time of writing (March 2007)

Within Tonga there is a western line of islands of volcanic origin, steep topography and generally high elevations, and an eastern line of generally low-lying limestone and mixed geology islands. Amongst the western group are Tofua (507 m), Kao (1030 m), Late (519 m), Niuafo'ou (260 m), Niuatoputapu (106 m) and Tafahi (548 m). The eastern group where the majority of the population lives consists of Tongatapu (65 m), 'Eua (312 m) and most of the islands of the Ha'apai and Vava'u groups. The Kingdom is divided into of four major groups, or clusters of islands: Tongatapu and Eua in the south, Ha'apai in the centre, Vava'u in the north and “the Niuas” (Niuafo'ou and Niua Toputapu) in the far north.

Tonga's archipelago lies along the boundary of the Pacific and Indian-Australian tectonic plates. It comprises both volcanic and uplifted coral islands and reefs, which cap the peaks of two parallel submarine ridges stretching south of Fiji.

Tongatapu and Eua are limestone capped or karst islands, and these combine with a number of small coral islands to form the Tongatapu group. Nuku’alofa, the capital is located on Tongatapu, the largest island in the Kingdom.

The south of the Vava'u group is generally composed of high volcanic and elevated limestone islands with reef communities or fringing reefs. Ha’apai has high volcanic and low limestone islands or atolls. The Niuas are high volcanic islands surrounded by fringing and barrier reefs.

1.2 Climate and hydrology

The climate of Tonga is semi-tropical. Tonga lies within the south-east trade wind zone of the South Pacific and its climate is dominated by south-easterly trade winds. Wind speed over its

surrounding oceans average around 12 knots. Strong winds are not common except during tropical cyclones in summer (November – April) and gales from eastward migrating high pressure systems during winter (May – October).

Rainfall is moderate, with high relative humidity, and is associated with the semi-permanent SPCZ (South Pacific Convergence Zone), the area of convergence between the equatorial easterly trades and the sub-tropical south-easterlies. Tonga's annual rainfall is defined by two seasons, the Wet and Dry seasons. The Wet season (also the cyclone season) occurs from November to April, and the Dry season occurs from May to October. The Wet season contributes to about two thirds of the total annual precipitation. The wettest months are January, February and March which may receive up to 2500mm of rain.

Rainfall is highly variable from year to year. Very low or high rainfall rarely persists for more than three months. Two predominant causes of rainfall variation in Tonga are ENSO (El Nino-Southern Oscillation) and tropical cyclones. ENSO events can cause prolonged drought whereas tropical cyclones can result in unusually wet years.

Monthly and annual rainfall vary from north to south of Tonga. The mean annual rainfall for the major island groups was calculated for 1947-2001 as follows: Nukualofa, Tongatapu received 1753mm; Lifuka, Ha'apai received 1689mm: Neiafu, Vava'u received 2185mm (Tu'i'afitu et al. 2005). See Annex 1 for monthly rainfall to 2007.

Data reflects a general decrease in annual rainfall in central and southern parts of Tonga particularly since the 1970s. Inter-annual variation in Tonga's rainfall has been associated with ENSO and the positioning of the ITCZ and SPCZ respectively. The major ENSO event in 1982/83 caused an extensive drought throughout the islands of Tonga, as in many other parts of the western Pacific (van der Brug 1983; Falkland 1989).

Temperature also varies from north to south. Mean temperatures in Tongatapu range between 21.4°C in July to 26.3°C in February. In Niuatoputapu, mean temperatures range between 25.5°C in August to 27.4°C in February.

Mean vapour pressures (and relative humidities) are highest in February and lowest in July. Sunshine hours, an indicator of solar radiation, are highest in the months of November to January and lowest in July, and average wind run is variable between months and islands.

Temperature records date back to 1949 for Nuku'alofa, Ha'apai, Vava'u and Niuatoputapu. An increase of 0.4 to 0.8˚C in annual mean temperature throughout has been noted for the island group since the 1970s. In addition, seasonal and extreme temperatures also indicate an upward trend.

Tropical cyclones occur in Tonga mainly during November -April. Between 1960 and 2006 there were 38 tropical cyclones in the Kingdom. There is an average of one tropical cyclone affecting Tonga annually. February is the month with the highest cyclone frequency in Tonga. During El Nino periods, the frequency of cyclones increase, as in the cyclone season of 2002-2003, when 3 out 5 cyclones caused severe damage to southern Tonga. (Tonga Meteorological Service 2007). See Annex 2 for cyclone records.

Water Resources The freshwater resources of the Kingdom of Tonga consist mainly of groundwater in the form of freshwater lenses. Freshwater lenses form on top of seawater in many of the islands due to the difference in density of the two fluids. The interface, or boundary, between the two fluids is not sharp but rather is in the form of a transition zone. Within the transition zone the water salinity increases from that of freshwater to that of seawater over a number of metres.

The thickness of freshwater and transition zones are dependent on many factors, some of which vary throughout the island groups and between islands within those groups. The most important are:

- rainfall amount and distribution

- quantity and type of surface vegetation and nature of distribution of soils (factors which influence evapotranspiration)
- size of island, especially width from seas to lagoon
- permeability and porosity of the geology, and presence of cave systems and solution cavities
- tidal range
- methods of extraction and quantity of water extracted by pumping

Surface water resources are only evident on some of the high volcanic and mixed geology islands in the form of springs and lakes. Crater lakes exist on the islands of Niuafo'ou and Tofua. It is reported that the former lake has been used in dry periods as a source of potable water. Surface water is collected from cave systems on the island of 'Eua and used for potable water supply.

Rainwater harvesting systems are a complementary freshwater resource, and an essential source of potable water on many of the islands. On some of the smaller islands in the Ha'apai and Vava'u groups they are the only source of freshwater.

1.3 Natural disasters: earthquakes, volcanoes and tsunamis

Tonga is threatened by other natural disasters besides cyclones

1.3.1 Earthquakes

Tonga lies close to the convergence of the Australian Tectonic Plate and the Pacific Tectonic Plate, at the Tongan Trench, which is one of the most seismically active areas in the Pacific region. Since 1902 there have been 17 earthquakes of Modified Mercalli (MM) intensity 8. Less severe tremors are common. The most recent earthquake to have a severe impact on the community occurred on June 23 1997. The tremor registered 7.2 on the Richter scale and affected Tongatapu and ‘Eua, causing damage to many buildings, including hospitals, churches, schools, homes and the wharves. Electricity and water supply infrastructure was also damaged and services disrupted. Tremors are amplified in areas of soft ground particularly around lagoons, mangrove swamps and reclaimed land.

1.3.2 Volcanoes

Tonga’s volcanic activity has been recorded since 1839, and includes submarine eruptions, and emerging and disappearing islands. In terms of impact on human settlement, there is an active volcano on the island of Niuafo’ou. The last major eruption occurred in 1946 which caused extensive damage to wireless station and other government buildings, dwellings and plantations. The entire population of 2500 people was evacuated, and many were settled on ‘Eua, but most people returned to Niuafo’ou in the following decade.

1.3.3 Tsunamis

Historical accounts indicate that approximately 20 tsunamis have affected many islands in Tonga, most waves been less than 1 m. An earthquake in 1919 is reported to have caused waves of 2.5 m in the Ha’apai Group.

1.4 Soils

Most of the islands of Tonga have a soil layer overlying coral limestone. The soils are mainly derived from andesitic tephra (volcanic ash). Other soils include coral sands and lagoonal sands and mud.

It is believed that the tephra was deposited by a series of volcanic eruptions from emergent volcanoes such as Tofua and Kao and from submarine volcanoes to the west. Two types of tephra are found, corresponding to two main phases of ash accumulation, one occurring earlier than 20,000 years ago and the other occurring between 5,000 and 10,000 years ago.

Generally, soils on the west side of the islands are thicker and have larger particle sizes while those on the east side are thinner and are made of finer ashes.

From a groundwater resources viewpoint, the relevant soil characteristics are: the rate of infiltration, the thickness and the moisture contents at both field capacity and wilting point.

The soils over most of the island are highly permeable and allow rainfall to readily infiltrate. Falkland (1991) reports an infiltration test at Mataki'eua on Tongatapu which showed that about 300 mm could infiltrate in one hour followed by 75 mm in a second hour. These infiltration rates are very high and are the reason that surface run-off does not occur except in local areas of compacted soils.

In some areas of the islands of Tonga, such as along the northern coast and around the lagoon of Tongatapu, the soils are far less permeable and ponded water is often found after rainfall. These less permeable soils cover a small proportion only of the islands and it can reasonably be assumed from a water resources viewpoint that surface runoff into the sea or lagoon is nil. The one exception is 'Eua where surface runoff occurs due to springs emanating at cave entrances in elevated terrain.

Field capacity (the maximum moisture content that soil can retain) and wilting point (the minimum soil moisture content to sustain plant growth) have been measured for a number of soils in different parts of Tonga.

Table 1: Soil moisture properties

Island	Field capacity (FC)	Wilting point (WP)	Available water (FC-WP)
'Eua	0.43-0.65	0.30-0.53	0.08-0.29
Ha'apai	0.49-0.64	0.27-0.50	0.14-0.23
Vava'u	0.37-0.60	0.30-0.53	0.07-0.15

Source: Falkland 1991

The differences for each island are due to both soil type and depth of sample.

Values of 55% and 40% were selected as reasonable estimates for field capacity and wilting point, giving the available water within the soil zone as 15%. These values can be used in water balance analyses.

As the soils on Tongatapu have physical properties similar to many of those found on other islands throughout Tonga, it is a reasonable approach to use average values derived from soils on other islands.

1.5 Vegetation

There is a wide diversity of vegetation types throughout the islands of the Kingdom of Tonga. A description of the various types of vegetation is given in ESCAP (1990) and the Tonga Biodiversity Stocktaking. Indigenous vegetation includes a variety of rootcrops, fruit trees such as mangoes, tava, and a variety of citrus, and native vegetables and grasses. In the settled areas of the four Island Groups, much of the native vegetation has been cleared for coconut plantations, home gardens, villages, and commercial crops. A significant percentage of the country is now under coconut in Panicum grassland.

From a water balance viewpoint, the vegetation can be classified as either shallow rooted or deep rooted. The shallow rooted vegetation which includes grasses, crops and shrubs obtain their moisture requirements from the soil moisture zone. The deep rooted vegetation consists of those trees whose roots can, where conditions are favourable, penetrate below the soil moisture zone and through the unsaturated zone to the water table. Coconut trees are a typical example of deep rooted vegetation on the islands of Tonga. In relatively shallow areas, coconut

trees typically have some roots within the soil moisture zone and some which penetrate to the watertable.

The significance of roots which can reach the watertable is that transpiration can occur directly from the freshwater lens, even during drought periods. Vegetation of this type is referred to as a phreatophyte and is common on coral atolls where the depth to the water table is typically 2 to 3 m. Coconut trees have been reported to extend their roots to a depth of at least 5.5 m. There is no direct evidence to substantiate the rooting depth of coconut trees in Tonga but it could reasonably be assumed that a proportion of the roots of coconut trees growing on areas of the islands where the depth to watertable is 5 m or less can reach the watertable.

On most parts of the main islands of the Ha'apai group the depth from the surface to watertable is higher being in the order of 5 to 8 m in many places and up to 15 and more metres in elevated parts of the islands. On Tongatapu the depth to watertable in the area close to the lagoon is less than about 5 m. However, in these low-lying areas there are not many deep rooted trees present in comparison to shallow rooted vegetation. On 'Eua and in the Vava'u the depths to water table are generally too high for roots to penetrate through to the watertable.

1.6 Agriculture, fisheries and food security

Agricultural production is the most productive activity in the economy of Tonga and continues to dominate the value-added contribution to GDP. The contribution was more than 40% in the 1980s however, it fell below 40% from 1993/94 to the present (Tu'i'afitu et al. 2005).

Rich volcanic soils on most of the islands provide a fertile base for production. Generally agriculture is rainfall dependent, and therefore highly vulnerable to the impact of drought (e.g. the poor squash yield in 1998 and food scarcity experienced during that period, especially in outer islands such as Ha'apai). Irrigation from groundwater is not commonly practiced, although some experimentation has occurred by the larger squash exporters. The most significant impact that agriculture has on the management of water resources is from the use of fertilisers and pesticides (See Section 3.1 of this report).

The agricultural sector is a source of domestic food supply, employment, cash income, foreign exchange earnings, and raw materials for processing and handicrafts. A significant percentage of economically active Tongans (58.4%) rely on primary production for their livelihood. Agriculture has consistently been the main foreign currency earner over many years. In the 1960's to 1970's, the main agricultural export crops had been copra and banana, then to be replaced by vanilla. Squash became the main export crop in the early 1990's along with vanilla, and in the mid-1990's kava became an important export crop, especially to expatriate Tongans living in the US, Australia and New Zealand. In recent years nonu also became an important export crop. Export statistics of the 1990's showed that traditional root crops have consistently been exported in substantial volumes.

Fresh agricultural produce is sold locally in market centres, or stalls on the roadsides. Daily supply is reliable unless production is interrupted by natural disasters. The price of local produce is not regulated which means a sharp rise in price can occur when supply is limited (e.g. when produce is sold out of season, or after a cyclone). These prices are sometimes beyond the buying capacity of low to medium earners.

Traditionally, all the household requirements from agriculture were provided by complex, robust, and productive farming systems which have provided inspiration for modern agricultural methods in developed countries such as "permaculture". These were typically multi-level rotational fallow systems utilising bush or grass fallow cover followed for several years by a series of rootcrops inter-cropped with coconuts and other tree species. They had proven very sustainable in the past, but with increasing population pressure, and land pressures for urban development, and introduction of large scale mono-culture crops such as squash, the fallow periods have shortened and fertility declined coupled with increasing pests and diseases (Asher and Halavatau 1997).

Food imports have been a concern in Tonga for many years both from an economic and health perspective. In 1999 it was over T$20 million per annum (Statistics Department 1999) and accounted for more than the total export. Meat is the largest import, particularly mutton flaps (off-cuts containing high concentrations of saturated fats), followed by cereal products, dairy products, and sugar and confectionery. It has been observed by local commentators "that Tonga does not import according to food needs but rather more because of luxury demands." The widespread consumption of these products is also a likely contributor to national health problems such as heart disease, obesity, and diabetes. Despite an abundance of local fresh fruit such as bananas and papaya, children are commonly given money for confectionary as their school lunch.

The sea and its coastal resources have sustained Tongans since the inhabitation of the islands. The ocean and its resources as well as the coastal areas (from 50 feet above high tide watermark) are Crown/Government property and the rights to all resources (sand, dead coral, marine life) are vested in the Crown (Constitution of Tonga and The Continental Shelf Act, 1970). However, in contrast to land access, there is a long-standing tradition of open access to marine resources.

The major marine ecosystems in Tonga are: algal and seagrass beds; fringing and lagoon reefs; rocky coasts; beaches; open lagoons; marine lakes; marine caves and a submarine trench. The reefs and lagoons are the prime fishery for subsistence supplies. In addition to fishing, a wide range of shellfish and other marine life are harvested from the tidal flats at low tide for consumption or for production of shell handicrafts for sale to tourists.

1.7 Economy

Tonga's economy, as a small island developing state was typically structured around a large public sector with dependence on remittances, and foreign aid. The economy grew at the average annual rate of 1.8% during the period 1973-1995, with per capita growth at 1.2%. Real GDP grew at the annual rate of 2.2% in the 7 year period from June 30 1994 to 30 June 2001; but growth rates ranged from minus 0.1% to 6.2%. The primary sector grew at just 0.4%; the secondary sector at 4.6%; and the tertiary sector at 3.5%. The government administration and community services sectors were the main contributor to growth. In 1996, full-time government workers accounted for 39% of the 13,318 Tonga employees who are paid in cash.

The inflation rate between June 1985 and June 2001 varied around average of 6.4%. Inflation was below 3% in FY1996 through 1998, but subsequently accelerated to over 6% in FY2001 and 10% in early FY2002 as a result of expansionary macroeconomic policies and substantial currency depreciation, drought and cyclone damage, and higher world prices.

In FY2001 a 20% civil service wage rise and below budget non-tax revenue collection increased the current budget deficit to almost 0.5% of GDP. The overall budget deficit was 2.6% of GDP and was financed by the domestic banking system, causing a rise in public domestic debt outstanding to 55%. In mid-2001, the external debt was US$63.6 million, or 44.7% of GDP. The debt service ratio was 12.1%.

The domestic currency, the pa'anga, is pegged to the currencies of the Australian, New Zealand, and US dollars and the Japanese yen. During the fiscal years 1991-2001, the pa'anga was devalued by 22% in nominal effective terms, and 10% in real effective terms. Most of the currency devaluation followed the private sector credit expansion of FY 1998 and the subsequent loss of foreign reserves.

A reduction in the public sector wage bill was considered necessary to allow for more expenditure on operation and maintenance. Downsizing of the public sector to increase efficiency has also been a policy supported by various donor agencies. In mid 2006, 1000 public servants accepted an offer of redundancy packages. The private sector and the community benefited from the initial expenditure of these lump sums. However by 2007, extended families previously dependent on the civil servant's wage are being forced to look for support elsewhere. It has been observed, both within and outside government that downsizing the public sector may be a more appropriate policy in an environment where there is alternative employment, a

financially robust government, and sufficient capacity among the remaining public servants to perform departmental responsibilities. But it is hoped that in the long term it will lead to a more efficient public service.

In addition, the riots of November 2006 resulted in the closure of many businesses, withdrawal of foreign investment, further unemployment and subsequent loss of excise, consumption and income tax revenue. The government now needs to raise funds for the reconstruction of the Nuku'alofa CBD. Donor agencies have offered technical advice to the Government and are pooling a fund for loans to affected businesses.

2 INTEGRATED WATER RESOURCES MANAGEMENT FOR TONGA

2.1 Water resources management

2.1.1 Types and uses of freshwater resources

The source of freshwater for Tonga is either through rainwater harvesting, or extracted from a thin freshwater lens within the highly porous limestone substrate. The water resources of Tonga are primarily in the form of groundwater. Surface water resources are not present on most islands; exceptions are 'Eua where supply originates from springs in caves high above sea level, and on a number of the volcanic islands including Niuafo'oua and Niuatoputapu and Tofua, where there are several salty lakes.

Groundwater occurs as freshwater lenses which form beneath the surface of the limestone islands and above seawater due to the density difference between freshwater and seawater. There is not a sharp interface between the freshwater and underlying seawater but rather a transition from one to the other. The transition zone is often much wider than the freshwater zone. Freshwater lenses can only occur where there is sufficient recharge from rainfall and where the permeability of the island's geological formation is not too high as to cause rapid mixing of the recharge to the freshwater and underlying seawater (Falkland 1991).

There are currently no functioning desalination systems in Tonga. Domestic greywater is commonly re-used for livestock especially pigs. A desalinator was provided to one of the island of Ha'apai by the Japanese government during the late 1980s but no provision was made for running costs.

Rainwater is commonly harvested from roofs and stored in household tanks, (previously in large communal in-ground stone water tanks) and used for drinking, and where sufficiently available for bathing, especially hair washing, and washing clothes. Bottled water is increasingly being imported from Fiji and Asia, but is mainly used by expatriates and tourists. Data on current bottled water imports was not available.

Groundwater is used domestically for cooking, bathing, washing food, watering plants (but not seedlings) and animals, flushing toilets, cleaning the house and vehicles. It is also boiled and used for drinking if rainwater is not available. It is piped to homes, government buildings, shops, industries and tourist accommodation by the Tonga Water Board in the urban centres of Nukualofa on Tongatapu, Neiafu on Va'vau and Pangai-Hihifo on Ha'apai and to villages on 'Eua. Many villages outside these centres have their own reticulated water system administered by water committees. The Tonga Water Board supply is metered at each property. Some villages are now introducing individual meters.

According to the 1996 Census, out of the total 16,194 households in Tonga, 84.6% (13,705 households) had access to piped water supply. A household may have access to piped water, and have its own water tank and/or well (Statistics Department 1999). The 1996 Census also recorded that 58.3% (9,444 households) had their own water tank; 2.4% (393 households) had their own well, and 1.1% (175 households) had other sources of water supply.

2.1.2 Issues and concerns

Each island within each island group has varying water resource issues and concerns depending on population pressures, demand, quality and quantity of water supply, local geology, agricultural and sanitation practices, and standard of extraction.

2.1.2.1 Exploitation and consumption. The greatest demand for water is on Tongatapu. According to the 1996 census, Tonga's total population was 97,784. Tongatapu has the highest population density and totalled 66,979 which accounted for 69% of the total population. Vava'u recorded 15715 (16%), Ha'apai recorded 8138 (8%), 'Eua recorded 4934 (5%), and the Niuas recorded 2018 (2%). As it is estimated that the population has grown by 46,000 people in the last decade it is possible that the population of Tongatapu has grown by up to 30,000 people. These figures can all be updated and verified when the 2006 census figures are released.

Water consumption per household per month, in the Nuku'alofa area was estimated at 0.03 ML in 1998. For the same year, in Nuku'alofa, it was estimated that 9.06 ML of water was for non-domestic uses, a total average of 87.67 ML was for domestic use, and 70.45 ML was unaccounted for (Tonga Water Board Database). The non-domestic water users were at the Small Industries Centre and from hotels, motels, and service stations.

Reticulated water supply for Nuku'alofa is drawn from a 146 acre well field at Mataki'eua/Tongamai, south-west of the town, with a network of 36 bores. There are pump sheds at each bore to protect the wells, but these are not locked. There are 3 electrically operated pumps and 33 diesel pumps. There is diesel storage at each bore which is refilled approximately every second day. Some cultivation/farming activities are conducted within the well field.

The current abstraction rate is 6-7,000 m^3 per day. An assessment of the water supply system by the Danish Ministry of Foreign Affairs concurred with some earlier recommendations for development of fifteen additional wells to bring production up to 10,000 m^3 per day to meet demand to 2026.

A draft of this report was published in February 2006 and a final report is anticipated in 2007. It is stated that the additional water production will still be well below the safe yield, which is reported to be 19,000 m^3 per day. It is anticipated that the new well production, along with additional storage, will alleviate pressure issues reported by some residents during the Socio-Economic Survey (SES) conducted by the ADB Urban Development Project (MOW/MOF 2006).

Table 2: Nuku'alofa Water Demand Projections

(Units are m^3/day)

	2005	**2007**	**2008**	**2010**	**2015**
Domestic Water Demand	2,832	2,898	2,922	3,035	3,330
Non-Domestic Water Demand	1,968	2,014	2,031	2,109	2,314
Total Demand	4,800	4,912	4,953	5,144	5,644
Unaccounted for Water	3,370	3,011	2,786	2,770	3,039
Required Water Production	8,170	7,923	7,739	7,914	8,682
Required Water Production (peak day)	10,212	9,904	9,674	9,892	10,852

Source: Appraisal of Water Supply Improvement Project – Kingdom of Tonga, Draft Appraisal Report, February 2006, Danish Ministry of Foreign Affairs, Secretariat for Mixed Credits referred to in MOW/MOF 2006.

The Tonga Water Board is responsible for water supply distribution, operation and maintenance in urban areas such as Nuku'alofa on Tongatapu, Pangai-Hihifo, 'Eua and Neiafu in Va'vau, and it also assists some village water committees maintain their systems in rural areas.

Upgrade and expansion of the existing water supply network was undertaken by a JICA funded project in 2001-02. In the 1990s AusAID funded the institutional strengthening of the Tonga Water Board in Nuku'alofa, Pangai-Hihifo and Neiafu, and the upgrade of premises in each

location including a fully equipped and staffed monitoring laboratory in Nuku'alofa. The water is pumped into six interconnected concrete ground reservoirs providing a storage capacity of 3,100 m^3 prior to distribution. Calcium hypochlorite is introduced directly into the distribution system immediately after discharging from these tanks. The chlorination dosing system often malfunctions and chlorine is then applied manually. Bacteriological testing occurs once per month, or as resources permit. A full contaminant screening, as recommended by the World Health Organization (WHO), is required to be conducted once per year.

Use of water for agricultural purposes is not recorded. Water drawn from village water supply systems is not metered. In 2006 some villages installed meters at individual homes but usage is not metered at the village pump. It is not known exactly how many bores are operating on Tongatapu, (or in the other island groups). In the last 8 years applications for new bores have been recorded, but it is not known what volume is being extracted. Application is made to the Lands and Natural Resources section of the Ministry of Lands, Survey Natural Resources and Environment for a permit to install a bore, the Ministry of Works drills the bore, or sometimes the Tonga Water Board hires a contractor to do the work. Of 33 applications for new bores since 1998, ten were for farming, but this is likely to be for livestock, rather than irrigation for agriculture. Bores can requested for private home, schools, churches, or village water supply.

2.1.2.2 Wastewater management and pollution control. There is no centralised reticulated sewerage system in Tonga. All wastewater is managed by on-site systems, with supervision by the Ministry of Health (MOH) when resources permit. In this respect wastewater management is in the hands of the community.

There are a small number of a small scale wastewater treatment plants (AWTS) at institutions, such Vaiola hospital, and at the new (solid) Waste Management Facility, but in Nuku'alofa sanitation systems are predominantly flush toilets with septic tanks and vertical soakaways. Some houses have both pit latrines and septic tank systems, and in the non-urban areas of Tonga many people still use pit latrines. The Tongan Integrated Urban Development Plan (TIUDP) Survey indicated 84% of the 431 households included in the survey use septic tank systems (MOW/MOF 2006) which correlates with the 1996 census figures.

Holding tanks for downtown restaurants and other businesses are reportedly pumped weekly or bi-weekly. Residential septic tanks are required to be pumped once every five years. Some tanks are never pumped because they have no base to the tank, or it has disintegrated over time. Sludge and effluent seep into the soil and groundwater. The TIUDP Survey indicates a range from annually to over ten years between pumping. The sludge was previously taken to the sludge beds at Patangata, but will now be treated at the new facilities at the Tapuhia Landfill. Septic tank inspections are conducted by the MOH. A total of 3,766 septic tank inspections were reported for 2004. However, MOH does not have enough staff to perform this many inspections and meet other MOH obligations. The numbers appear to indicate the number of septic tanks pumped out, and only random spot checks are conducted for compliance.

Septic tank building plans are reviewed by MOH as part of the building permit process. Previously, there was minimum direction provided to individuals concerning septic tank design and construction. In 2005 a Manual of Residential Septic Tank Practice for Tonga was published (Belz 2005). This manual provides basic information on the sizing and construction of septic tanks and soakaways for typical Tongan soils. In addition, the National Building Code for the Kingdom of Tonga (NBC) is currently before Parliament, and contains specifications for septic tank design and construction. The recent TIUDP SES indicates a number of tanks are undersized. It is generally assumed that numerous tanks have been improperly constructed prior to the requirement for formal permit procedures.

Septic tanks were introduced from developed countries such as Australia and New Zealand in the 1960s. Since then, the use of septic tanks in these countries has been significantly controlled after serious pollution impact over many years. These restrictions and requirements have not been passed on to the island countries which adopted the systems. A conventional septic tank does break down organic material and reduce some pathogenic organisms, if it is

designed correctly with a treatment trench, and is working properly, but it does not remove most of the nutrients or pathogens. Consequently, these contaminants can be introduced into the surrounding environment, including ingress to groundwater.

There is a freshwater lens under Nuku'alofa, which is one of the reasons for the settlement there. In the past it was a reliable source of good quality water which households accessed through hand dug wells. With the introduction of pits latrines and septic tanks, and an increase in population density, the lens became polluted, and was generally abandoned as a water source in favour of a reticulated water system, sourced from outside the town. However some households still use their well water, particularly in the drought or to save money on TWB water bills. Water form specific wells is traditionally valued for the treatment of eye infections such as conjunctivitis, and there are spiritual/cultural associations with the household well. The household wells are banned by MOH.

Generally, the public health threats of nutrient and bacteriological inputs into the groundwater in Nuku'alofa are indirect at this time. Excess nutrient loads appear to be impacting the environmental health of the near shore reef in the Nuku'alofa area, and the lagoon in general. Algal growth can be seen in both areas. In addition, there are concerns that fish harvested in these areas, particularly shellfish, may be contaminated.

A direct threat to human health from septic tanks can be observed during high rainfall/high tide events which inundate soakaways and bring contaminants to the surface. This exposes people to significant risk of contracting waterborne diseases due to direct contact with contaminants in the floodwaters.

The Ministry of Health reported 543 cases of disease on Tongatapu in 2004 that could potentially be water borne, including one case of typhoid. The report did not identify where on the island the patients may have contracted the illnesses or what the potential transmission source is, but epidemiological investigations concluded the transmission source was likely to have been food. In general gastroenteric disease is not reported as it is believed to be a result of over eating, especially of fatty foods.

The TIUDP report has advised that groundwater contamination from septic tank effluent may not be an emergency at this point, but efforts should be commenced now to implement a phased process of eliminating this potential source before a serious epidemic does occur. The TIUDP survey indicates there are some residents using shallow wells for their water supply and there are large numbers of people living near wetlands or standing water that is at an equal hydraulic gradient with septic tank soakage pits. There is a concern that these people in particular could be vulnerable to an outbreak of waterborne disease.

A long term concern with the current sanitation practice is the potential for contamination of the aquifers designated for TWB and village reticulated supply. The TWB has reported no faecal indicators in tests taken to date. However, as production rates increase and development moves closer to the well fields leading to changes in the groundwater gradient there is the potential for drawing contaminants toward the wells. Monitoring of wells and village water supply in other parts of Tongatapu, have shown the presence of faecal indicators. While there are plans to create buffer zones, steps also need to be taken toward control of contaminants at the source.

Similar pollution issues exist in the other island groups, particularly Ha'apai where studies have indicated significant contamination of groundwater from septic tanks, pit latrines and pigs. This is exacerbated by over-pumping. As a result of theses studies people were required by MOH to close their private wells, but this is very much resisted as the wells are a traditional and valued source of free, fresh water.

The TWB improved supply in Ha'apai by installing infiltration galleries. However, when available, people will use rainwater and well water as a first preference, regardless of biological pollution problems. In Ha'apai, the TWB groundwater supply is least favoured for the following reasons:

- is too 'hard' for many purposes;

- rusting or damaging of utensils, feeder tanks, metal fittings in bathrooms, or toilet rooms;
- sediment forming in containers, kettles, and blocking holes in shower heads necessitating use of bucket bathing;
- pressure too low at peak times such as bathing in the morning before church or work; and
- occasionally 'bad smell' or 'hospital smell' and milky appearance, and associated rashes from chlorine.

The above concerns are sometimes expressed by users and communities in the other TWB serviced areas such as Nuku'alofa.

Dry sanitation options (non-waterborne, zero discharge treatment) such as composting toilets (CTs) have been introduced in Tonga over the last decade. Fifteen units were trialled in Pangai–Hihifo in the late 1990s as part of the Institutional Strengthening Project of the Tonga Water Board funded by AusAID. Four of these systems are still operating successfully. The community of Ata'ata, in the Tongatapu group observed the trial and subsequently installed CTs for each house and school in the village in 2001. These toilets are still being used and the community is generally satisfied with the technology. During the International Waters Project 2001-2007, personnel and community members visited the island of Ata'ata and examined the construction of the CTs, reviewed usage with the community, and decided to replicate two units in the focus village as part of their waste management and pollution control activities.. Subsequently there have been 20 more requests for CTs which CanadaFund has agreed to provide. There are current negotiations to be settled as the community is resisting paying 20% of material costs, which is required by the project.

Introducing new toilet technology is a challenge in any culture. Toilets habits are learnt at a very young age and there are many taboos and beliefs associated with excretion, and excreta. In Tonga the widespread introduction of CTs is commonly resisted for the following reasons:

- flush toilets with septic tanks are considered a status symbol;
- attempts by some residents to install CTs inside a new home has been obstructed by the lending agency as banks in Tonga will only lend money for construction of houses which include septic tanks;
- in areas where CTs have been introduced such as Ha'apai, other projects have been initiated at the same time, or soon after, offering flush toilets with septic tanks and promoting contradictory information about health and environmental impacts;
- CTs require more work in that bulking agent (for aeration and carbon/nitrogen balance) needs to be added after every use;
- CTs are perceived by some to be just an upgraded pit latrine (which is why it would be useful if the system could be installed in a new house within a modern bathroom, as a promotional model);
- if not properly maintained CTs can smell, and attract flies and cockroaches. However this can apply to any badly maintained toilet.
- CTs may be accepted by one generation in a family but if there are household changes the new generation or occupants may not understand how the system works or its benefits. This occurred in Ha'apai and resulted in a number of well functioning systems been abandoned.

Over the years, there have been recommendations for a reticulated sewerage system in Nuku'alofa and other urban areas throughout Tonga. However the cost and complexity of this is currently prohibitive, and it may cause as many health and environmental threats as it would solve. It is difficult enough to maintain a reticulated water supply, and a reticulated sewerage system may cause additional problems.

2.1.2.3 Information exchanges on water resources. According to personnel involved in water management, there is no functioning information or data exchange systems on water resources. Data and information are exchanged to fulfil requirements for externally funded projects such as the current development of the Water Safety Plans. However on a daily basis this does not necessarily occur.

Information is occasionally exchanged between individuals from various sectors who are friends or related, if required to write a report, develop a proposal, or undertake a specific task.

2.1.3 Measures to manage impacts and concerns (IWRM approaches)

2.1.3.1 Assessment and monitoring. There is no 'National Hydrological Network' for water resources assessment and monitoring. Water resources are currently managed by a number of institutions, some of which have specific or general monitoring, as follows.

- *The Hydrogeology section of the Ministry of Lands, Survey Natural Resources and Environment (MLSNRE)* is responsible for the assessment and monitoring of physical and chemical parameters (salinity, pH, temperature) and watertable elevations, of the water resources throughout Tonga, and for advice on development and management of water resources, including permission to install bores. The quantity extracted is not monitored outside TWB serviced centres. Samples have been occasionally collected to assess for chemicals such as pesticides, but these have to be sent to New Zealand or Australia for testing, which is expensive and inefficient. Monitoring is limited by available skilled staff, transport including fuel for transport, and equipment.

  An automatic tidal recorder is located on Vuna wharf, Nuku'alofa. This recorder provides a continuous trace showing the fluctuations of the sea level due to tidal, barometric and other influences. The ongoing operation of the recorder is useful for groundwater monitoring (as well as for other purposes). The tidal and barometric variations can be used to determine the tidal lags and efficiencies at different locations within the groundwater body. The information is stored in the Geodesy section at the MLSNRE.

- *The Tonga Water Board (TWB)* is responsible for the planning, installation, operation and maintenance of public water supply systems in connected urban areas of Tongatapu, 'Eua, Ha'apai and Vava'u, and provides technical assistance to some village water supply committees in rural areas. Supply is metered at each household, pH and salinity are monitored intermittently by the TWB staff in some of the TWB service centres.

- *Ministry of Health (MOH)* is responsible for implementing and maintaining village water supply schemes, and for monitoring and surveillance of the biological quality of public water supply schemes. Water samples should be collected by MOH inspectors from designated sites on a regular basis. They are tested at the Ministry's laboratory located at the Vaiola Hospital on Tongatapu. Testing only includes the presence of faecal indicators. There is no testing for specific pathogens such as protozoa or viruses which can remain in water long after faecal indicators test absent. In practice, due to limited human and technical resources, the MOH assesses each village water supply systems approximately twice a year. Only nine water samples can be tested each month as the hospital laboratory is also used for all other biological tests for patients. If there is an incident of disease in an area, such as typhoid, or severe widespread gastroenteritis, the water supply will be tested by MOH.

- *The Central Planning Department (CPD)* is responsible for the overall coordination and monitoring of aid projects, and for coordination of development plans including those affecting the water sector.

- *The Tonga Meteorological Service (TMS)* is responsible for operation and maintenance of the climatic stations in all the island groups, and collects data on rainfall, droughts, temperature, and cyclones. It has access to rainfall data at the MLSNRE and the TWB.

- *The Water Resources Committee* is a subcommittee of the Development Coordination Committee (to be designated as the National Water Authority under the Water Resources Bill which is before Cabinet), and is responsible for initiating and reviewing development and other proposals related to water resources, and making recommendations to the Development Coordination Committee.
- *The Ministry of Works (MOW)* owns and operates the only drilling rig used for installation of bore holes.
- *The Waste Management Authority* will be responsible for the management of solid waste, which includes the new waste management facility at Tapuhia near Vaini on Tongatapu which has an aerated wastewater treatment plant treating leachates and dispersing the treated effluent by irrigation. Groundwater at Tapuhia is monitored to ensure leachate is not impacting on groundwater. Closure of the previous waste dump will allow for restoration of the associated coastal area.
- *A Planning and Urban Management Division (PUMD)* has been established within the MLSNRE. The initial role of the PUMD is to assist with the re-construction of Nuku'alofa, but its longer term role will be more wide-ranging and not just landuse planning in its usual sense. Planning for growth in urban areas also means urban management, sanitation, planning for the sustainable use of resources including water, and community participation and liaison.
- *The Ministry of Agriculture Forestry and Fisheries (MAFF)* is responsible for promoting agricultural production and supervising use of fertilisers, pesticides and irrigation. They have no facilities for monitoring contamination of groundwater by pesticides and fertilisers, or records of who is using irrigation systems.
- *The Ministry of Finance (MOF)* is responsible for the national budget including capital and recurrent funding of water supply and water resource programmes.
- *Village Water Committees* are responsible for the operating and maintaining the technical components of village water supply systems. Generally, there has been minimal organised community monitoring of quality apart from individual observations on taste, smell, colour or sediment. Some villages are now installing water meters at households to measure consumption and charge accordingly.

  On 'Eua, the community water committee monitored colour and sediment of the TWB supply in the preliminary stages of the 'Eua Water Supply Project and will continue to do so in the coming five year trail period that TWB will operate the new supply system. At the end of five years the community will decide whether the TWB has performed satisfactorily, and if not the community will take over management of the water supply system.

  A 'Workshop on Introduction of Community-Based Water Quality Assurance' conducted by WHO in May 2005 introduced two simple tools: the hydrogen sulphide or 'H2S' bacteria screening test and 'scored sanitary survey' checklists, which can be used by communities to monitor their water supply (groundwater and rainwater) and wastewater management.

  Traditionally, there has been community monitoring of household hygiene by village women's groups. Homes and villages are inspected and scored. In anticipation of these events, homes and the village are rigorously cleaned. Condition of toilets, bath houses, and management of solid waste is included in the assessment. This process can indirectly contribute to protection of water quality, and could be built upon to initiate more direct community monitoring of water resources.
- Householders manage their rain harvesting systems, wells and connections to the reticulated supply.

- NGO and CBOs are involved in community based water schemes.

2.1.3.2 Water conservation and re-use. Where metered groundwater is conserved the motivation is generally to avoid high water bills. There appears to be little sense of common ownership and responsibility for the resource and this is one of the negative outcomes of transfer to a reticulated supply. People often do not report leaks in the TWB system, but some people say this is because the response is slow.

Rainwater is used by most families, but the collection systems are sometimes not well maintained e.g. gutters and downpipes are not connected or repaired, only part of the roof area is connected for catchment, tanks are not protected from animals, especially pigs, and the tanks become undermined and develop cracks. Neglect is most common where the tank has been supplied, free of charge, by an aid project. There can be an expectation that the aid project will maintain the system, and supply another tank and collection system if the old one deteriorates. Tanks which have been paid for by the family, or there has been some substantial monetary or labour contribution are generally well maintained. A rainwater harvesting project was conducted in the Vava'u Group through the Village Women's Development Programme (VWDP) of the Tonga Community Development Trust, in 2002-2003 funded by the Swedish International Development Agency (Sida) through UNEP. SOPAC was the executing agency and produced guidelines for development and maintenance, and a manual for community engagement (SOPAC 2004).

Water from private wells is generally carefully conserved, and traditionally valued, especially if it is drawn by hand. Where motorised pumps are installed for private use, over-pumping can occur and is usually only controlled if the water becomes noticeably salty.

Greywater is sometimes re-used to feed pigs and water household gardens, but there is no reticulated re-use system.

Protection of water resources. The TWB well fields are located in relatively undeveloped areas, or partial reserves, such as Mataki'eua, but there is no buffer zone between the well field and potential development, and housing and farming activities are not entirely excluded on the reserve areas. The area which the well field covers is unknown. It is possible that contaminants from the re-charge zone could reach the aquifer. There are sheds to house the pumps but these are not locked, and sometimes oil and fuel spills occur in the vicinity of the pumps. Some of the wellheads and casing are old and cracked These issues are being addressed in the current project to develop Water Safety Plans, which is being funded by AusAID and conducted through the Tonga Water Board and the Ministry of Health, with WHO and SOPAC as executing agencies. The steering committee consists of representatives from TANGO, (Tonga Association of non-government organisations), TWB, MOH, Natural Resources, Environment, the Tonga Trust, and Disaster Management Services (SOPAC 2007). Water safety plans are being developed for Nuku'alofa and rural areas.

Village water supply is generally sourced from outside the village, but the reason for this is to avoid the sound of the pump. People are not generally aware of the potential impact of their activities on groundwater. Pigs are allowed to roam in the well field areas which can causes erosion, and possible faecal contamination. In some villages water is extracted 24 hrs/day and the holding tank is allowed to continually overflow. As the villages grow, development is encroaching on the well fields. In some villages such as Utula and Kahoua, the water supply system is located within the village. Rubbish dumps, septic tanks, pit latrines, livestock especially pigs, fertilisers and pesticides used in village gardens, and spilt fuel all threaten the quality of the groundwater.

As sanitation is managed almost entirely by the householder through the use of on-site systems, a concentrated and extensive campaign is required to graphically demonstrate the links between inadequate, poorly maintained or inappropriate technology and the spread of disease-causing organisms. The fact that these organisms are invisible to the naked eye is a significant barrier to understanding. The beliefs and attitudes associated with excreta management will also need to be carefully addressed. In addition the means to do something about this unseen contamination should be provided through practical skills courses in the

design construction, application and maintenance of a range of commonly used on-site sanitations systems. For example in Australia any household with a septic tank system is required to have one of its members attend a 2 day workshop on proper maintenance of the system. One-off trainings of this nature for a group of around 25 people have occurred in Fiji, Vanuatu, Tuvalu and Kiribati in recent years, but the skills and understanding should be extended to all households in the same way that car drivers are expected to learn to drive a vehicle before they are issued with a licence.

2.2 Island vulnerability

2.2.1 Types of disasters

Many of these issues have been covered in Sections 1.2 and 1.3. Disasters or emergencies which could affect water resources in Tonga are repeated and summarised below.

- Chemical pollution from pesticides and fertilisers, oil, fuel, industrial chemicals due to the porous nature of the soil, and the high watertable in some areas.
- Accumulated biological pollution from septic tanks, pit latrines, and pigs could reach a critical point so that an aquifer has to be abandoned as in the case of the Nuku'alofa township aquifer.
- Cyclones which occur in the kingdom on an average of once a year can inundate low-lying areas causing surcharge of sewage and other contaminants causing an increase in diarrhoea, and saltwater intrusion of groundwater reducing potable supplies. Extensive damages has been caused by cyclones on schools, dwellings and other buildings, the agricultural sector, water supply, power, telecommunications, fisheries and government offices and properties. Increased rainfall during cyclones and other storm events can enhance breeding of insect vectors such as mosquitoes, which may result in outbreaks of dengue fever. Surface run-off and erosion can increase saltation on fringing reefs.
- Earthquakes can cause leaks in rainwater tanks and household plumbing, break up underground piping causing water loss and allowing possible ingress of biological and chemical pollution from the surrounding environment.
- Extended drought reduces re-charge of groundwater, concentrates contaminants, reduces food production for subsistence and income, and may increase incidence of communicable diseases due to in adequate water for hygiene purposes.

Climate data. Records of earthquakes are kept by the seismology section of Natural Resources at MLSNRE. National data on cyclones, rainfall, temperature, and droughts is recorded by the Tonga Meteorological Service. Data on tides and sea level is recorded by the geodesy section of MLSNRE.

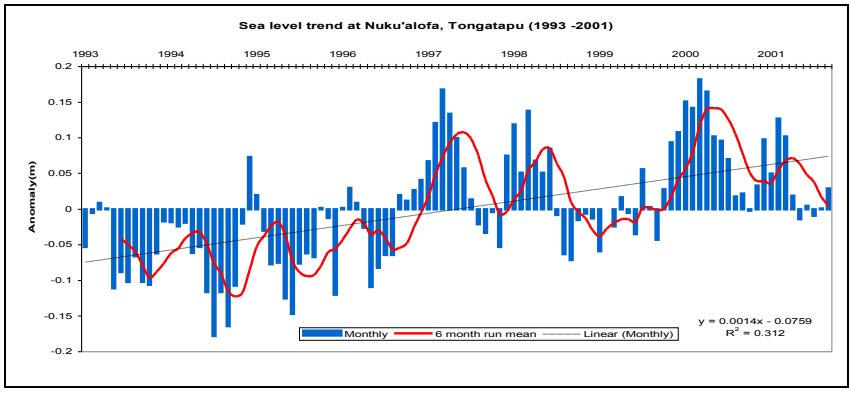
Historical temperature trends for Nuku'alofa, Vava'u, Ha'apai and Niuatoputapu date back to 1949. Trends suggest a marked increase of 0.4^0C to 0.8^0C in annual mean temperature throughout the island groups since the 1970s.

Annual precipitation trends obtained from spatially selected meteorological stations throughout Tonga over 30 years indicate a general decrease in annual rainfall in the central and southern parts of Tonga particularly since 1970s. There has been an indication of a decrease in seasonal precipitation throughout the Kingdom.

Inter-annual variation in Tonga's rainfall has been strongly associated with El Nino Southern Oscillation (ENSO) and the positioning of the ITCZ and SPCZ respectively.

Correlation has been observed between the Southern Oscillation Index (SOI) and Nuku'alofa rainfall. As the SOI increases, rainfall patterns follow a La Nina type pattern. The converse (El Nino type rainfall pattern) is also true for observed negative SOIs.

Figure 1: Sea level trend for Nuku'alofa, Tongatapu



Source:

The sea level trend (Figure 1) indicates a general increase in sea level of 14 mm/yr since records commenced in 1993 up to 2001. This is compared with a global average of 1-2 mm/yr. However the magnitude of the trend continues to vary from month to month. The result in August 2004 shows a trend of +11.6 mm/yr (South Pacific Sea Level and Climate Monitoring Project).

The following observation was made in the *National Communication under UNFCCC* "It should be noted however that data recorded is far too short to suggest a true representation of sea level rise in Tonga. Longer term data record is desirable to ensure noise from ENSO cycles and various local atmospheric, oceanographic and geodetic processes are limited before better estimates can be made. The current figure is expected to decrease as more credible data will be collected. Despite this limitation, it can still be observed that data obtained from the tide gauge, to date, signifies a positive sea level trend. The projected sea level rise accompanying climate changes due to the enhanced greenhouse effect are expected to adversely affect almost all the islands of Tonga" (Tu'iafitu 2005).

Historical records indicate an increase in tropical cyclone frequency in the South West Pacific since the 1960s. This trend could be attributed to improved recording of such events through the introduction of advanced technologies e.g. geostationary and polar orbiting satellites and changes to tropical cyclone definition. There also appears to be a relationship between increased cyclonic activity and El Nino events, however a longer data set is required to make a definite prediction regarding increased cyclone activity.

Economic impact of water-related disasters. The economic impact of water-related disasters such as cyclones is evaluated. For example, tropical cyclone Isaac, in 1982 caused damage of T$18.7 million (US$10.5 million) in the Ha'apai and Tongatapu Group. Tropical cyclone Ofa in 1990 severely affected the Niua Toputapu group, with an estimated cost of T$3.2 million. Tropical cyclone Cora in 1998 hit the Tongatapu, Ha'apai and 'Eua Groups and damages cost T$19.6 million. Tropical cyclone Waka in 2002 severely damaged the islands of Niuafoou, Niua Toputapu and Vava'u and the total estimated cost for the damage was T$104.2 million. (Natural Disaster Management Report 2002).

Houses and tourist accommodation built close to the coast have been destroyed in cyclones on Tongatapu and Ha'apai. Tourists prefer to have water views and immediate access to the beach, but in some cases this kind of development has exacerbated erosion during high tides and led to the whole construction being washed away in cyclones.

Beach mining for sand and aggregate (dead coral) have also increased the impact of storm surges on coastal areas.

2.2.2 Major issues and concerns

These issues are already discussed in the previous section.

Currently groundwater water resources on Tongatapu and Va'vau are adequate, even through drought periods. However on small outer islands and the atolls of Ha'apai water resources are threatened by drought and potential saltwater intrusion.

Extreme events such as storm surges, high seas and gale force winds combined with projected mean sea level rises, will probably increase the incidence of wave overtopping or inundation of low-lying areas.

This has already occurred on Tongatapu especially during El Niño episodes. Storm surges during 1982 and 1998, particularly in the hurricane season (November – April), caused inundation of land in the low-lying areas of the northern part of Tongatapu, and especially the western end of Nuku'alofa (Sopu, Halavave and part of Kolomotu'a on the lagoon side). Recent regular inundation of low-lying parts of the northern part of Tongatapu occurs during El Niño episodes Overtopping by waves or inundation by high sea levels has caused seawater intrusion into freshwater lenses hence reducing the availability of potable freshwater.

Sea level rise could inundate land, resulting in land loss and reduction of the size of the freshwater lens, affecting quality and quantity of supply. Loss of land could result in overcrowding in urban areas and associated public health and environmental deterioration as has happened in the low-lying areas of Nuku'alofa. Increased proximity of the freshwater lens to land surface may result in greater concentrations of contaminants.

Coastal villages on the western side of Tongatapu are less than 5 m above sea level and have been flooded by a tidal lagoon which has inundated town and tax allotments, resulting in the abandonment of houses, and crops.

2.2.3 Measures to manage impacts and concerns

A National Emergency Management Plan has been developed which builds on the 1987 national disaster plan, and a National Emergency Management Committee has been formed (NEMC) and a National Emergency Management Office has been established within the Ministry of Works (MOW). The Deputy Director (NDMO) is responsible for the following activities.

- Managing the development, testing and review of operational support plans.
- Coordinating the development of education and awareness programmes related to disaster management.
- The identification and conduct of disaster management training courses, including the selection of participants for regional international courses.
- Providing technical assistance and advisory service to departments, NGOs and other agencies on disaster management matters.
- Assisting with the identification and implementation of disaster mitigation programmes and activities.
- Serving as a focal point for regional disaster management issues.
- Developing a national resource register of government.
- Other disaster management related duties as directed by the Minister or Director.

The Emergency Management Act (2006) is currently before Cabinet. The deputy Director Mr Maliu Takai is currently on the Water Safety Plan committee and was consulted during this diagnostic review and has agreed to be a member of the IWRM National Water Committee. The Tonga Water Board and the MLSNRE are included on the National Emergency Management Committee so there is the opportunity for exchange of water-related information and support when they meet.

There are a number of adaptation options and strategies that can be considered to cope with possible future impacts of climate change and sea lever rise on water resources. The options considered here deal with water issues in the country and are linked to economic efficiency and environmental benefits, and need to take into account cultural and social suitability and practicability.

Adaptation options identified and discussed cover water resources in the outer islands and large islands of Tonga and include:

- Demand management measures. Demand management is generally more cost effective than alternative source development. By reducing the demand for water or by ensuring more effective use of existing sources, there will be less pressure on limited water resources. These measures are recommended regardless of whether there is an emergency or climate crisis.
- Leak detection control work is necessary ongoing activity in the management of the reticulated system. The TWB has had thorough leak detection programmes funded by donors, and continues to undertake this work.
- Effective community education and engagement is essential to achieve sustainable water resource management. Conservation is ultimately in the hands of the consumer. Relevant programmes and activities will be discussed in Section 4 of this report.
- In urban centres like Nuku'alofa where public water is supplied to the consumer, a pricing policy has been developed as an effective way of managing demand to include low-income earners and others. Village water supplies are also introducing meters so that more care is taken with usage.
- Water conservation plumbing devices such as spring loaded taps, low flush cisterns, and low flow shower heads can be fitted in homes, businesses, government department and tourist accommodation. These are being installed in some new buildings in Tonga, including new homes and renovations. Seawater can be used in flush toilets instead of freshwater in order to save potable water. However this can result in biological problems in septic tanks. Alternatively, dry sanitation systems such as composting toilets are being used on Ha'apai and Tongatapu to avoid wasting water on flushing, and to ensure zero discharge to the environment. They are easy to construct, and free to maintain but are often rejected for cultural/social reasons, as previously discussed.

Augmenting water supply. Adaptive measures aimed at developing additional or supplementary freshwater resources, or maximising the use of currently available resources include the following:

- Expansion of rainwater harvesting systems, which includes construction of new holding tanks and catchment, areas and improved maintenance of existing systems. See previous sections and Section 4 for reference to rainwater harvesting activities.
- Groundwater protection measures include: establishing reserves and buffer zones for well fields and re-charge zones, and this is being discussed in the development of Water Safety Plans; planning for more sustainable land use which is being considered under the Urban Tonga Integrated Urban Development Project, especially in relation to the reconstruction of Nuku'alofa. (if planned and controlled development is to extend beyond the CBD, it will require considerable negotiation between government and private landowners and agreement on appropriate administrative, legal and financial agreements and will need to take into account traditional considerations regarding land, (see Section 6); source control is also required to protect groundwater especially regarding the impact of inappropriate sanitation systems, roaming pigs, and rubbish dumps (as discussed in previous sections); protection of coastal areas to ensure island margins are not eroded, and freshwater lenses are not reduced in quality or quantity.
- Ongoing groundwater monitoring and assessment.

Forecasting and prediction. Drought vulnerability assessments could be undertaken for the island groups, and climate forecasting would also assist with disaster preparedness.

Institutional and regulatory support is required to effectively prepare for and manage disasters, and to reduce the impact of climate variability on freshwater resources. Bills and Acts have

been developed which support a sustainable approach. They require approval, and funding allocated for implementation.

2.3 Awareness

Wastewater management is almost entirely in the hands of the householder as all sanitation treatment in Tonga is on-site. In regard to water management, most households have a rainwater tank, and some have their own well. Management of reticulated water is also dependent on the behaviour of the consumer. Education is conducted through public meetings, school presentations, TV programmes, theatre, and radio broadcasts. However it is also necessary to actively engage householders and the wider community, and provide them with the tools to sustain their resources.

2.3.1 Types of awareness campaigns related to water resource management

Examples of advocacy initiatives and awareness campaigns follows:

- The International Waters Programme, which finished in February 2007, was conducted through the Environment Department, and had an extensive community engagement component, focusing on the conservation of freshwater resources through effective solid waste management. Two composting toilets were also trialled in the project community of Nukuhetuly on Tongatapu which has resulted in requests for another 20 toilets (IWP 2003, 2006).
- The Solid Waste Management Project, conducted through the Ministry of Works is continuing the work started by the IWP team, and has ongoing activities including newsletters, videos, school programmes and work with village committees. Surveys and workshops have been conducted on such issues as the use of disposable nappies (diapers) which have been a significant waste management problem, and are often dumped in lagoon and coastal areas.
- A ground water pollution study was conducted in the late 1990s in Ha'apai at a community school, funded through UNESCO and conducted by a team from the Hydrogeology Unit at MLSNR, the TWB and MOH. The children were involved in the installation of monitoring bores and the collection and testing of samples. The children observed the rate and direction of the flow of groundwater, and were able to see and understand why contaminants from a septic tank or pit latrine could travel to a water supply source such as a well. There has been an intention to repeat this activity in other schools and locations but to date it has not happened (IHP-V 2001).
- A rainwater harvesting campaign was conducted through the Tonga Trust in 2002-4. There are ongoing activities based on the manual, guidelines and video which SOPAC developed from the project.
- There is ongoing installation of rainwater systems through the AusAID small grants program facilitated through various NGOs, and CBOs, such as Village Women's Committees. Revolving loans have assisted families to contribute to construction.
- The national women's organisation Langafonua has also been actively engaged in supporting the installation of rainwater harvesting systems by assisting women to raise the necessary funds to contribute to construction. The effort required to raise this money usually results in more long term care of the system, than projects where rainwater tanks are provided free of contribution.
- The TWB has conducted radio programmes encouraging people to report leaks, and generally discussing consumer issues.

2.3.2 Major issues and concerns

On the islands of Tongatapu and Vava'u water supply is not a top priority issue. People complain about low pressure, or the cost of reticulated water, but water is rarely in short supply.

So it is taken for granted, and it is difficult to convince people that they need to conserve water, and protect the common resource.

On the outer islands and the atolls water is highly valued, because the communities regularly experience limited supply or poor quality.

People do not always make the link between polluted water and disease, partly because there are varying views as to what causes illness, and also because the water looks clean and pathogens cannot be seen. There is also limited understanding of the physical nature of an aquifer as it also cannot be seen (which is why the Ha'apai groundwater pollution study had such an impact).

There are certain taboos which prohibit communication about personal issues between male and female relatives. As many people are related this can mean that a Health Inspector on a small island may not be able to discuss sanitation and hygiene with many of the local population. This also applies to radio and TV programmes about sanitation issues.

Community participation and consultation is usually conducted as a requirement for donor based activities, but it is not always a routine approach in daily government/utility activities. However communities in Tonga have a long established participatory tradition focused around the Town Officer and village committees and decisions regarding most aspects of village life are made collectively. The strength of this system varies from village to village. Involvement in church activities is also a collective and consensual activity, and a significant force for social cohesion. Community participation programmes are usually more effective if they work through these associations.

There is usually a strong focus on women's' involvement in donor funded activities, however it can become a burden on women to be involved in project committees, as they still have their domestic and other duties to perform. Even though women and girls are primarily responsible for sanitation and hygiene in the home, water and sanitation programmes should involve all family members including the men.

It is reported that there is limited political will to address water resources management, and that politicians concentrate on the source of reticulated water such as Mataki'eua but have less interest in village water supply unless it directly affects them or their families.

Manuals and guidelines developed for community participation in water and sanitation are often too complex and wordy and do not recognise the preference for oral communication in the Pacific culture. Consequently these publications are not used. Similarly, lengthy documents such as this diagnostic report are not likely to be read by the people for whom are they are written.

2.3.3 Measures to manage impacts and concerns

There is a need to re-connect with traditional values regarding protection of resources. Consultation with the focus community during the IWP project encouraged stories about past connection with the water and the land. A walk through the village with community members revealed that there was a hand dug well 5 m deep which was now filled with rubbish. It would have been totally unacceptable to treat the well in this way, when the village was dependent upon its wells and this resource had sacred connotations. Discussions about the community's history helped to rekindle pride in their village and a desire to address environmental damage (IWP Tonga 2003).

Householders need to become aware of threats to public health and the environment but they also need to have the skills and resources to do something about the problem.

Activities which provide these skills have much more chance of being sustainable beyond the life of an externally funded project.

Village water committees are actively involved in operating their water supply, but they need technical training in maintenance and monitoring. Some maintenance training has been provided through the TWB but more is needed, and training in monitoring is also required.

A risk-assessment/risk-management approach to ensuring safe drinking water was introduced to Pacific island countries in a workshop in February 2005 organised by WHO. 18 countries met in Nadi, Fiji, and completed a 'Pacific Framework on Drinking Water Quality and Health' to guide future activities and attract donor support. The meeting of Pacific Islands Health Ministers endorsed the 'Framework' two months later. Three water quality programmes have since been proposed.

The 'Pacific Water Safety Plans Programme' began in late 2005 under AusAID funding to WHO and SOPAC. This two-year joint program is piloting Water Safety Plans in at least four Pacific island countries, including Tonga. The plans focus on reticulated town water in Nuku'alofa, and rural water supply. It is intended that this will give village water committees tools to identify problems and work toward solutions.

A 'Workshop on Introduction of Community-Based Water Quality Assurance' which was conducted in May 2005 by WHO introduced two simple tools: the hydrogen sulphide or 'H2S' bacteria screening test and 'scored sanitary survey' checklists, which can be used by householders to monitor rainwater.

The village water committee in 'Eua has been active in monitoring its water supply under the 'Eua Water Supply Project, funded by NZAID, and is receiving training in public relations and maintenance.

2.4 Technology

Most of the information required in this section has been covered in previous sections e.g. Section 2.1 so a summary is provided here.

2.4.1 Types of water supply systems

A reticulated supply is provided to the urban areas of Nuku'alofa, Pangai-Hihifo, Neiafu and 'Eua by the Tonga Water Board. The source is groundwater which is gravity fed to a metered connection at the customers premises. The Nuku'alofa supply is operated by diesel and electric pumps, and the other TWB service areas have diesel pumps, although solar pumps have been used in Pangai-Hihifo. Water is treated with chlorine.

Many villages in Tonga have a reticulated water supply sourced from aquifers outside the village, and operated with diesel pumps. Water is not treated.

Some institutions (boarding schools, churches) and households outside the village areas have their own bores and diesel operated pumps connected to a holding tank and gravity fed to the premises. The water is not treated

Reticulated water from TWB and village water systems is delivered to 80% of households.

Rainwater harvesting systems are connected to 60% of households. Water is not treated.

Wells provide supplementary water supply to 3% of households. Water is not treated.

2.4.2 Types of wastewater/sanitation systems

- Concrete and fibreglass septic tanks with vertical soakaways provide settling of solids and some breakdown of organic matter, but minimal reduction of pathogens and nutrients. Effluent from the tanks disperses through the soakaway and into the surrounding soil, and groundwater (if in proximity). Tanks should be desludged every 3-5 years but in practice it can be left for more than 10 years or not desludged at all.
- Holding tanks particularly for restaurants and businesses in Nuku'alofa which are pumped out once a week and the sludge was previously collected and dried at the Nuku'alofa dump. Sludge will now be treated at the new Waste Management Facility.
- Pit latrines
- Ventilated pit latrines

- Pour flush toilets with direct soakaway
- AWTS Small scale aerated waste water treatment systems (4 known of in Tonga)
- There are no reticulated sewerage treatment systems in Tonga

2.4.3 Major issues and concerns

There is sufficient supply to meet demand in the TWB serviced areas of Tongatapu and Va'vau.

On the outer islands and atolls where there is increased or total reliance on rainwater harvesting, then shortage is experienced in times of drought.

The village water supply committees require financial and technical assistance and-on the-job training to establish and maintain their systems. There are many instances of poor maintenance which could impact on quality. Extraction rates or quantities are not controlled.

Low income families require financial assistance to establish and maintain rainwater harvesting systems. All householders can benefit from technical training in system construction and maintenance.

Current sanitation systems leach nutrients and pathogens into groundwater especially in the low-lying areas and on atolls. Studies have shown that there is no safe distance between a pollution source such as a septic tank and a water supply source (such as a well) in villages of the population density which is common on atolls in Tonga (IHP-V 2001).

It was previously believed that the rate of flow in groundwater was slow enough that pathogens would die off if a distance of 30 metres was maintained between toilets and wells. However only bacteria was taken into account, and the resilience of other disease-causing organisms such as viruses and protozoa in water was not understood.

Waterborne diseases are common in Tonga, and algal blooms appear in the lagoon and on the coast. These problems could be attributed to inappropriate sanitation systems, but pollution would also be coming from pigs.

Institutions such a MOH and the Hydrology Unit require technical and financial assistance to adequately monitor biological and chemical pollution of water resources, and rates of extraction.

2.4.4 Measures to manage impacts and concerns

The MOH is responsible for testing TWB and village supply systems but due to lack of human and technical resources this only happens approximately twice a year for each village**.** The TWB water supply is required to be tested once a month. Testing for specific pathogens is not undertaken. Testing for thermo-tolerant coliforms is used in Tonga as a faecal indicator, (and in many parts of the world), but this method is currently being discarded in some developed countries, as it is considered to be an unreliable indicator of the presence of pathogens (Standards Australia/New Zealand 2007)

Apart from this occasional monitoring, and outdated guidelines for locating of toilets in relation to water supply sources, there are no measures in place to prevent pollution from poorly managed wastewater.

Non polluting dry sanitation systems such as composting toilets have been trialled, and accepted in some instances, but there has not been a concerted campaign to introduce them on a wide scale. Strategic marketing is required to overcome socio-cultural prejudices, and develop a non polluting sanitation system for Tonga.

There are existing Geographical Information Systems where water resources information is being stored, and this data is held at the Hydrogeology Unit, MLSNRE. Location and description of known boreholes are recorded. Further work is required.

As discussed in previous sections there is a need for demand management measures, such as leak detection, community education and encouragement to encourage conservation, metering and appropriate pricing, promotion of water-saving plumbing devices and waterless zero-discharge toilets.

Capacity building in asset operation and maintenance is required for reticulated water supply systems. Training for householders is required in design construction use and maintenance of on-site water supply and sanitation systems.

2.5 Institutional arrangements

Institutional issues relating to water resources management need to be seen in the broader institutional and legal context which currently exists in Tonga.

In 2006 the institutional and legal situation in Tonga was in a state of flux. A number of structural reforms were enacted in response to the fiscal crisis of 2005. These have included the appointment of the first non-noble Prime Minister, the first female minister and the first non-Tongan minister.

Following his appointment in March 2006, the new Prime Minister, Dr Feleti Sevele introduced more commoners to his Cabinet and in other senior positions, such as the Public Service Commissioners.

On July 1st 2006 the Government downsized the public service. Around 1000 staff accepted voluntary redundancies and the 27 Ministries and Departments were consolidated into 14 Ministries, some with multi-sector portfolios.

The new ministerial structure announced in March 2006 is summarised in Table 3. Under the new structure each ministry has a Minister and a Chief Executive Officer (CEO). The appointments for these posts were intended to take place on July 1st 2006. However these were deferred until 2007. Heads of Departments' contracts were also extended to the end of 2006, and the identification and appointment of new Heads/CEOs was ongoing into early 2007.

Table 3: Tonga Government as Restructured on 1st July 2006

Ministry	Changes
Prime Minister's Office	Retain the previous structure, except the Women and Development Centre - which will be transferred to the Ministry of Education.
Finance and Economic Planning	Retain the previous structure.
Foreign Affairs and Defence	Retain the previous structure, and merge with the Tonga Defence Services.
Lands, Survey, Natural Resources and Environment	Retain the previous structure, and merge with the Department of Environment.
Justice and Attorney General	Retain the previous structure.
Police, Prisons and Fire Services	Retain the previous structure.
Education, Women's Affairs and Culture	Retain the previous structure, except the Training, and Youth and Sports divisions - which will be transferred to the new Ministry of Employment, Training, Youth & Sports; and merge with the Women & Development Centre of the Prime Minister's Office.
Health	Retain the previous structure.
Agriculture, Food, Forestry and Fisheries	Retain the previous structure, and amalgamate with the Ministry of Forestry and the Ministry of Fisheries.
Labour, Commerce and Industries	Retain the previous structure, except the Employment function – which will be transferred to the new Ministry of Employment, Training, Youth and Sports.

Ministry	Changes
Tourism	Retain the previous structure
Works	Retain the previous structure
Transport	New Ministry by amalgamating the Ministry of Civil Aviation and the Ministry of Marine & Ports (road transport to be included from July 1st 2007).
Employment, Training, Youth and Sports	New Ministry by merging the Employment function of the Ministry of Labour, Commerce & Industries, and the Training and Youth & Sports divisions of the Ministry of Education.

Source: Integrated Urban Management Report (MOW/MOF 2006)

In addition to the administrative reform described above, there has been significant political reform including an increase in the number of people's representatives in Parliament from the current 9 to 14 and a reduction in the number of Cabinet Ministers directly appointed without election.

These changes followed consultations which were undertaken during the first half of 2006 by the National Council for Political Reform (NCPR) throughout Tonga and in Tongan communities in Australia, New Zealand and the USA. The NCPR's report was presented to the late King Tupou IV shortly before his death on 10th September, and to Parliament over several sessions in October.

In November 2006 riots occurred in Nuku'alofa associated with the pro-democracy movement. Fires were lit that got out of control and burnt down large areas of the CBD and a number of people were killed. Many businesses and government property were looted and destroyed.

These events, in addition to the death of the elderly King in September, (and of his son and daughter-in-law in a car accident earlier in the year), brought the country and especially the public service virtually to a standstill and it is only now in early 2007, that routine activities are beginning to be resumed.

In regard to water resources management there have been a number of direct institutional impacts from the events and reforms of the last 12 months.

- The Department of Environment has merged with the MLSNR to become MLSNRE which may potentially contribute to a more integrated and sustainable approach to resource management, including water.
- 47 personnel from a staff of 125 have resigned from the MLSNR including one of the experienced hydrogeologists at the Unit. Some information and data is lost or difficult to find because the people who managed it for many years have resigned, and the remaining staff are adjusting to new responsibilities and multiple roles.
- There is considerable backlog of legislation before Cabinet including the Water Resources Bill.
- There is a shortage of money available for routine tasks.

2.5.1 Types of institutional arrangements

There is no 'National Water Vision' as such. There have been several Water Master Plans prepared over the years. There is currently a Water Safety Plan (WSP) steering committee preparing Water Safety Plans for Nuku'alofa and rural areas. On the committee there are representatives from the following organisations:

- Tonga Water Board - 3 reps: (Chairman, TWB chemist, WSP coordinator)
- Ministry of Health - 1 rep
- Natural Resources - 1 rep (Hydrology/Hydrogeology unit)

- Environment Department - 1 rep
- National Disaster Management Office - 1 rep
- Tonga National Association of NGOs (TANGO) - 2 reps
- Tonga Trust –1 rep

As the meetings are held on Tongatapu, there are no representatives from the other island Groups.

There is currently no over-arching national water resources and water services policy. Various organisations have specific responsibilities and are individually mandated as listed in previous sections. The four main institutions/associations are as follows:

- The Tonga Water Board is responsible for the planning, installation, operation and maintenance of public water supply systems in urban areas of Tongatapu, 'Eua, Ha'apai and Vava'u and its roles and responsibilities are mandated by the Water Board Act 2000, including the right of enforcement as follows: “Establishes a Water Board charged with the principal responsibility for the provision and management of water supplies in designated areas The Board must operate in accordance with a plan prepared every 3 years. Provision is made in relation to water supply issues including the right to take water from waterworks, water restrictions and powers to enter land. Regulations may be made in support of the activities of the Board”
- The Ministry of Health is responsible for implementing and maintaining village water supply schemes and for monitoring and supervising the biological quality of public water supply schemes. The MOH’s primary role is to provide free medical services to the community. Through Health Inspectors from its Environmental Health Division, it is also responsible for water supply, rubbish collection, waste disposal, and street cleaning in Nuku’alofa CBD (all to be taken over by Waste Management Authority when it is established) as well as rural and urban sanitation. Its roles and responsibilities are mandated by the Public Health Act 1992, including the right of enforcement.

  The Public Health Act 1992

  “Makes comprehensive provision in relation to water quality issues.

  The Minister for Health is responsible for determining which sources of water are suitable for public water supplies. Regular steps must be taken to ensure the adequacy and wholesomeness of water supplies.

  All premises must have a sufficient water supply.

  Authorised Officers are required to examine all sources of water including wells, boreholes, rain water storages and streams.

  Potable water supplies must be certified under this Act and no person may use a source of water for public water supply without certification.

  Village water committees must be given advice on measures for ensuring supplies of safe drinking water and the prevention of contamination. Closure of unsafe water supplies and other corrective measures may be ordered.

  Piped water supplies are regulated.

  The Ministry must carry out regular sampling of water including a physical and chemical analysis, examination for harmful micro-organisms and the radioactive content.

  The Water Supply Regulations 1963 are saved by the Public Health Act 1992 and deemed to be made under the new Act. This reflects the continuing role of the Ministry of Health in relation to the provision of rural water supplies”

- The Village Water Committees are responsible for operating and maintaining the physical components of village water supply systems. There is no specific legislation to cover these responsibilities.
- The Ministry of Lands, Survey and Natural Resources and Environment is the agency responsible for assessment and monitoring (quantity and physical and chemical quality) of water resources throughout Tonga and for advice on future development and management of water resources. In particular, the Hydrogeology Unit of this Ministry undertakes all the detailed technical assessment of water resources, establishes and maintains relevant databases concerning water resources development and monitoring and advises the Ministry on development proposals which impinge on the water resources.

However there has been no clear mandate as to who is responsible for managing water, despite recommendations for this to be resolved from many different stakeholders over the last 15 years. Hence there is no right of enforcement or mechanism to ensure funds are provided by Finance to effectively perform duties.

2.5.2 Major issues and concerns

There is no comprehensive law in Tonga dealing with issues of ownership, management and protection of water resources. This is despite the fact that the need for such legislation has been clearly highlighted in various documents, national consultations and conferences since 1991. Provision is made in relation to pollution of water in a number of laws and these laws involve a range of government agencies.

In the absence of appropriate institutional arrangements, the following issues are of concern.

- Although the Ministry of Health has clear responsibility for monitoring water quality in accordance with its Act, the Act does not specify the water quality standards that are to be applied, nor does it require the publication of test results. The functions of the Water Board and Ministry of Health are currently performed under appropriate legislative arrangements. However there is no right of access to information about water standards and the results of water testing. It appears to be in everybody's interests that the information is made public. Among other advantages this would allow measures to be taken to avoid problems before they become serious.
- Within the Water Board Act there is no provision for community involvement to be an integral feature of the required three-yearly operation plan. Voluntary community cooperation in resource management is essential as enforcement in general is rarely practiced in Tonga due to the extended networks of family relationship within the community and general aversion to confrontation in the work context.
- It is has been observed on many occasions and by various stakeholders that it is difficult obtaining information from other agencies. Record keeping, information sharing and rights of access to information needs to be facilitated so a coordinated approach to conservation and management can be achieved.
- There is no effective control of boreholes including extraction rates or wastage.
- Licensing of drillers needs to be more strictly controlled to ensure quality work is conducted.
- There are no legal controls on the size of pumps and on locating them to ensure that high extraction rates do not affect the balance of freshwater and saltwater in the lens, or result in drawn down of contaminants.
- There is minimal understanding or supervision of pollution of groundwater from pesticides, fertilisers and septic tanks.

- There is no urban management control/planning mechanism to restrict development based upon the availability of water supplies and possible adverse effects on the groundwater. (Any restrictions on use of land and water would need to be negotiated with landholders and take into account traditional land tenure practices).
- The hydrogeology unit does not have a mandated budget to pay for the necessary staff, transport, and equipment to effectively perform its monitoring and resource management duties.
- Members of community water supply committees often do not have the necessary technical skills and understanding to protect and manage their resource. They also struggle to fund basic maintenance of the system. The hydrogeology unit could provide on the job training and support if it had sufficient staff. (TWB has provided training to some village water committees under donor funded upgrade programmes).
- There are no integrated drought proofing measures in place.
- Without legislative support and an integrated institutional framework it is difficult to attract funds to ensure effective and comprehensive water resource management.
- Water quality cannot be assured in the promotion of tourism.

The following relevant recommendations were made in the 1992 Review of Tonga's Legislation.

Recommendation 16 "It is recommended that legislation be considered to clearly detail the responsibilities of the Ministry of Lands, Surveys and Natural Resources to control and protect water resources".

Recommendation 17 "It is recommended that the recommendations made in the Tonga Water Supply Master Plan to improve the present institutional arrangements and to amend the legislation should be considered with a view to implementation" (Government of Tonga 1992). In March 2007 these recommendations are still outstanding and the problems associated with lack of implementation continue to impact upon the country's water resources.

2.5.3 Measures to manage impacts and concerns

During the International Waters Programme, the IWP team consulted with all stakeholders to develop and refine the Water Resources Bill, incorporating all previous legislation.

The key elements of the Water Resources Bill are as follows:

- Ownership of the water resources by the Crown;
- The right of the Crown to control the water resources;
- Rights of the Water Board and other State utilities to access water resources;
- The regulation of other means of access to the water resources and the rights to use the resources;
- Determination of matters involving competing claims to the water resource;
- Imposing water restrictions and drought control measures;
- Regulation of any activity likely to affect the water resources;
- Powers to order the cessation of any activities likely to affect the water resources;
- Standards of water quality – human health, general environment;
- Offences in relation to water pollution and contamination and for other breaches of this law.

A wide range of powers are given to the Minister of Lands, Survey Natural Resources and Environment to manage, protect and conserve the water resource. The powers cover the following matters:

- Approvals for the taking of water
- Determination of competing claims to the water resource
- Placing restrictions on taking and using water
- Setting standards applying to the taking of water
- Declaring water source protection zones and providing for their management
- Regulating and controlling the use of water and activities which affect the quantity and quality of water
- Ordering that activities which adversely affect the water resource cease.

To support implementation of the Water Resources Act when it is passed the following capacity building will be required:

- Training of village water committees in monitoring and maintenance of water supply system
- On-the-job training in hydrogeology and hydrology for staff at the Resources Division of the MLSNRE with adequate equipment to conduct water resource assessments throughout Tonga, maintain comprehensive monitoring and support an integrated approach to management of water resources and wastewater.
- Ground water resources database maintained by the Hydrogeology Unit should be updated with all water resources information including surface water flows, rainfall and climatic data. This will enable all water resources data to be stored centrally and allow data analysis to be undertaken in a more effective way.
- Community liaison skills to negotiate with landholders to achieve cooperative management of water resources.

Work has been undertaken in Tonga by the Environment Department and others to respond to international treaties which Tonga has ratified. A draft law providing for the implementation of the Cartagena Protocol has been prepared regarding biosafety and the control of living modified organisms. The issues of ozone layer protection and the control of ozone depleting substances under the Montreal Protocol have also been addressed in drafted laws. Work has commenced in relation to the control of persistent organic pollutants in accordance with the Stockholm Convention and this shall lead to the drafting of appropriate legislation in due course.

In general legislation and regulation is only effective if it has community support, as enforcement is problematic in small communities where many people are related and confrontation, especially in the workplace, is avoided.

2.6 Financing

2.6.1 Types of financing arrangements

2.6.1.1 Tonga Water Board. Unlike the electric energy utility, the TWB is not subsidised, but it manages to cover its running costs, and contribute to consolidated revenue. Sources of revenue are water sales, contracts for services such as upgrading village water supply, training village water committees, and selling plumbing and fittings.

A typical household connection would be charged as follows.

1. ‘Line charge’, or meter rental - T$3.00
2. Water used 16,162 units @ .00151 cents - T$24.40
3. Fuel surcharge - T$7.81
4. Consumption tax 15% - .45 cents TOTAL T$35.64

Domestic consumers who use <20,001 litres are charged consumption tax on the meter rental only. Over 20,001 litres domestic use attracts consumption tax on all charges. Commercial consumers are taxed 15% on all the charges.

The TWB has received substantial financial assistance from international donors. For example: AU$5 million for Institutional Strengthening of TWB from AusAID in the mid 1990s; US$9 million for Nuku'alofa reticulation infrastructure upgrade from JICA in 2000-2004 and NZ$5.5 million for 'Eua water supply.

Information in this section is limited to what was made available by the TWB Accountancy section.

2.6.1.2 Village water supply. A flat rate of 10 pa'anga a month is charged to each connection. Some villages are now connecting meters to houses so that charges can also be made for usage.

Village water supply systems are installed or upgraded through grants from JICA annually. Typically US$60,000 for each village and an average of eight villages covered each year. The projects are managed by the Central Planning Department, and TWB or other contractors are hired to do the work. Some water supply systems which have been upgraded are at schools.

NZAID also contributes to installation and upgrade of village water supply especially in three villages where there had been typhoid outbreak.

2.6.1.3 Rainwater harvesting. Rainwater harvesting systems are funded by small grants from AusAID, approximately AU$700,000 per year, and from NZAID NZ$50,000 per year, administered through NGOs such as Tonga Trust and Langafonua. Langfonua assisted women to conduct fundraising campaigns to pay for their contribution towards construction. This included catering for workshops and social functions. Revolving loans were also established within women's groups.

2.6.2 Major issues and concerns

2.6.2.1 Re Tonga Water Board: tariffs are unchanged since 2002. Running costs are increasing especially the price of fuel. TWB staff have advised that there is a need to increase tariffs. The question is whether consumers will be willing to pay. In terms of the household budget, it was observed that water bills are low priority. Electricity comes first, followed by fuel, food, church donations and then water. The TWB has been dependent on donor agencies to fund infrastructure.

2.6.2.2 Re village water supply. Insufficient funds to properly maintain systems and protect resource.

2.6.2.3 Monitoring and Management. There is insufficient funding for water conservation and demand management activities, and a lack of financial support to water resources managers.

2.6.3 Measures to manage impacts and concerns

2.6.3.1 Tonga Water Board. Measures are being taken to reduce administrative and running costs. It is recommended in the Strategic Development Plan (SDP8) for 2006/07 -2008/09 to "review water pricing by TWB to clarify cost and appropriateness of holding below that which generates a commercial rate of return."

The only other reference to water in the SDP8 was: "to complete a full upgrade of the Nuku'alofa and Va'vau water supply" There was no reference to resource protection, water conservation or demand management.

2.6.3.2 Village water supply. Villages which have installed meters report that people are taking more care with wastage, and more likely to pay their water bill which improves supply for everyone.

When the Water Resources Act is implemented, improved management and monitoring should assist in reducing direct costs by improving efficiency, and reducing indirect costs by protecting quality.

2.6.3.3 Rainwater harvesting. In recent times emphasis has moved from supply of system to involvement and training of communities in all stages of the project, including design and construction. It has been observed that it is necessary to allow enough time for the community to go through the necessary process to make a commitment.

3. LINKAGES TO OTHER AREAS

3.1 Landuse and agriculture

There is no specific land use policy which has special emphasis on management of water resources. Tonga has a complex traditional land tenure system which needs to be taken into account when land/water use is considered.

The King is the owner of all land in Tonga. The King and the Royal Family retain ownership of the 'King's Estate' and the 'Royal Family Estate', and these lands are not available for subdivision or leasing. 'Nobles' Estates' are derived from a grant of land hereditary from the King. Land in the nobles' estates can be subdivided, allocated and leased.

There are also 'Crown/Government Estates' where land has been acquired from the King and hereditary estates and applied to a public purpose (for example, roads, parks, cemeteries, schools and government buildings), and coastal land. This is governed by section 138 of the Land Act.

Every male Tongan over the age of 16 years has an entitlement to a town allotment and a tax allotment held as a life interest that is passed down through hereditary rules specified in the Land Act. This provision places a restriction on the Government in terms of land supply, and due to growth of population and shortage of land there are many males entitled to land who can no longer acquire it.

3.1.1 Extraction of water

In regard to water resources, commoners or nobles can agree to water being extracted from their land, for a village water supply for example. Agreements between landholder and water committee are individually negotiated and range from a costly rental arrangement to a free grant of usage, which may be passed down from generation to generation of male landholders. Although an heir can decide to terminate the agreement made by his father or uncle, the original agreement is often maintained out of respect for forebears. Other agreements may be less amicable and result in a landholder cancelling the right of extraction even where lease fees have been paid. Ultimately control (and protection) of groundwater is at the discretion of the landholder, but in practice it is the activities of the village community which impacts on the water resources.

Villages are defined by the outer limit of groups of lots that have been registered as town lots. However the village in many people's perception also includes the rural tax allotments that belong to the villagers, which can be spread over a wide area. These are not necessarily continuous with each other or with the town lots, so drawing a line around a 'village' can be difficult.

In urban and peri-urban areas water is extracted for small industries, tourist accommodation, and domestic use, but in rural areas, the main use of groundwater is for village water supply systems. Applications for bores can be justified for "farming" but this usually means watering stock, rather than for agriculture. Some of the large squash farmers have experimented with irrigation but generally rely on direct rainfall. The cost of fuel and maintenance of pumps and pipes is a disincentive for installing irrigation systems, and there does seem to be some awareness that intensive extraction for irrigation could lead to saltwater intrusion.

3.1.2 Use of agrichemicals

The use of pesticides and fertilisers is the main concern in relation to the impact of agriculture on water resources. Squash production has resulted in a substantial increase in imported

agrichemicals: T$700,000 was spent on pesticides in 1999-2001 and T$1million on fertilisers in the same period. Application of fertilisers has grown from 5 kg/hectare at the end of the 1980s to 80 kg/hectare at the end of the 1990s There is anecdotal evidence that eutrophication of the lagoon at points where groundwater is seeping through may be caused by artificial fertilisers.

It is also likely that effluent from septic tanks is an additional contributing factor. Traces of pesticides such as lindane, DDT, aldrin, and heptachlor (now banned) were found in well water in 1984, and traces of organochlorines were found in sediment and shellfish of the central Fanga'uta lagoon in 2002 (van der Velde 2006).

It is also assumed that coral die-off can be attributed to a combination of nutrient run-off from urban and agricultural sources.

Concentrations of nitrates draining from the root zone of squash were measured to be approximately five times the WHO limit for drinking water quality. Traces of deildrin, diazinon and carbyl were also found (van der Velde 2004).

3.1.3 Deforestation

Less than 4% of Tonga's indigenous forest is left and most of that is in a National Park on 'Eua. The remainder occurs in very steep or otherwise inaccessible areas on the coast, in mangrove swamps and on the slopes of volcanic lakes. Much of the country is now under coconut in Panicum grassland.

Due to limited availability of land, mangrove areas in Tongatapu and Vava'u have been subdivided and cleared and filled to make home sites. This has resulted in a reduction in the quantity of fish caught in these areas. Pit latrines and septic tanks in these villages regularly surcharge due to flooding, causing a serious health threat to residents, and releasing further nutrients into the coastal areas There has been some re-generation of the mangroves, and now that a rubbish dump on the edge of Nuku'alofa has been relocated to a waste management facility, efforts will be made to rejuvenate that coastal area.

A reforestation policy aimed towards providing local timber needs and reducing overall loss of foreign exchange has resulted in over 300 hectares of exotic trees being planted in 'Eua.

3.2 Habitats and ecosystems

A number of habitats and ecosystems are threatened by inadequate management of water resources and wastewater.

3.2.1 Coral reefs

The coral reef ecosystem is one of the most diverse on earth. It supports millions of species in both the plant and animal kingdom, providing shelter, food, breeding and grounds. Coral reefs also protect the islands from storm surges, currents, and wave action. In Tonga the reefs also provide the main source of aggregate and sand for construction.

3.2.2 Seagrass/algae communities/mangrove forests

A high percentage of seagrass in some areas of Fanga'uta lagoon on Tongaptapu is covered with epiphyte which indicates pollution in the lagoon. High sedimentation rate from run-off brings dirt and organic materials into the lagoon, thereby causing epiphytes growth on seagrasses. The run-off has a triple impact: Fanga'uta lagoon is becoming shallower due to sedimentation; recent studies indicate that the residence time for affected areas in the lagoon is 21 days; and the sediment combined with seepage from groundwater carries a high nutrient load. It can trigger algal bloom and ultimately eutrophication.

There is a low percentage coverage of seagrasses Halophila and Halodule spp within the affected area indicates the direct effects of epiphytes on seagrass. Algae such as halimeda and caulerpa spp are also suffering the same impact from the BLANK

The lagoon is semi-enclosed and has two channels which connect to the open sea. It takes 21 days for a body of water to stay in the lagoon before finding its way out to the open water. The

current speed and direction within the lagoon has not been quantitatively determined. However, experience with the lagoon shows that the current is weak and the direction of flows is dominated by the tidal flow. (IWP Tonga 2005b).

The quality of life in the lagoon depends very much on the protection and preservation of the mangrove forest. The mangroves also act as a filter for sediments and contaminants, as well as habitat for fish, crabs, sponges, barnacles, oysters and snails, and serve as physical protection against storm surges and coastal erosion.

The lagoon is protected under the Birds and Fish Preservation Act of 1974, but this has not been observed by the community, as it has been overfished for commercial and subsistence purposes, mangroves have been cut down, and land reclamation has caused significant disturbance and pollution.

Under the Parks and reserves Act of 1976 five marine parks have been designated on Tongatapu. The parks cover 250 hectares of coral reef, which is 10% of Tonga's total coral system. None of the other island groups have marine parks although surveys have been conducted with this intention in mind.

A comprehensive stocktaking of biodiversity in Tonga was undertaken by the Department of Environment in response to the United Nations Convention on Biological Diversity (CBD), which Tonga ratified in May 1998. The National Biodiversity Conservation Strategy (NBSAP) aims to formulate through a participatory and analytical process, the strategies necessary for the protection and sustainable use of the biodiversity in Tonga, and prepare a plan for implementation.

Biodiversity is seen as the 'capital' needed for development and maintenance of local communities and from which all income (cash and non-cash) is derived. This requires restoring and nurturing traditional sustainable approaches to management (Prescott et al. 2004).

3.3 Health and hygiene

As discussed in previous sections the main health concern related to watershed and wastewater management is pollution from inappropriate sanitation systems, and agricultural and industrial chemicals.

Water borne, water-washed and water related diseases include dengue fever (from mosquitoes), typhoid, skin infections such as ulcers, boils, ringworm and other fungal infections such as ringworm, gastroenteritis, diarrhoea related illnesses, and food poisoning.

Table 4: Number of Typhoid Cases for Tonga (2000-2006)

Year	Number Typhoid Cases For Tonga
2000	10
2001	14
2002	5
2003	21
2004	2
2005	6
2006	4

Source:

Diarrhoea is one of the leading causes of death in children under five as indicated below.

Table 5: Number of Deaths from Diarrhoea (1997-2003)

Year	Number of deaths
1997	724
1998	1567
1999	1588
2000	1983
2001	1452

2002	1396
2003	1036

Source:

In 1999 and 2000 the incidence of diarrhoea related diseases peaked during drought conditions leading to the assumption that reduced water supply had led to unhygienic conditions and practices in many communities. This may have been exacerbated by greater concentration of contaminants and drawn down from point source of pollution such as septic tanks to water supply sources such as wells and village pumps.

It has been observed that dengue outbreaks are more common in cyclone seasons when hot humid conditions are favourable to reproduction.

3.3.1 Tourism in relation to water and waste water management

The tourism industry is one of the major contributors to Tonga's economy. Numbers peaked around the millennium celebrations. Although the number of tourist arrivals has declined since 1999 (see figure 2) the foreign exchange earnings are still significant. Tourism numbers dropped after the November 2006 riots but are gradually returning to normal for this time of the year. There is an average of 43,000 arrivals annually, predominantly by plane rather than by sea due to improved air services to Tonga.

Table 6: Tourist Arrival and Foreign Exchange Earnings from Tourism (1996-2002)

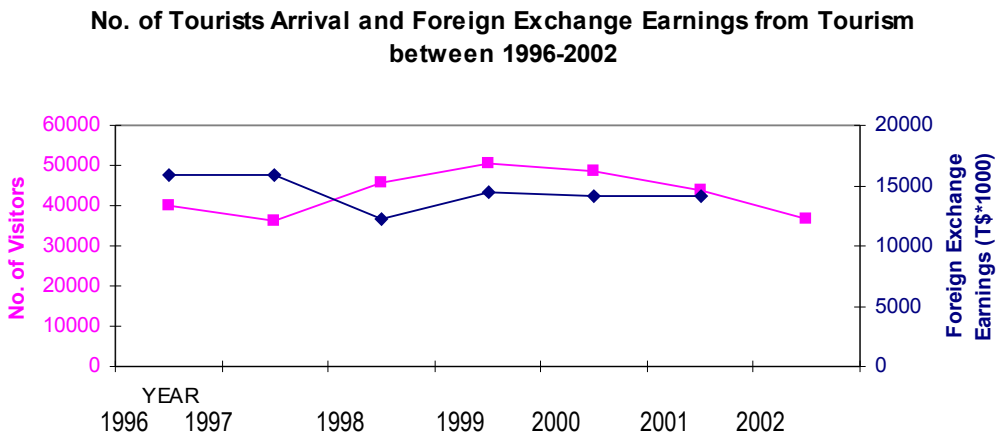
Source:

Tonga Visitor's Bureau (TVB) has identified strategies which include developing new eco-tourism products such as eco-resorts on outer islands, introducing minimum standards to improve tourism services and products including hygiene and sanitation; and coordinating the development of tourism as a major sector.

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
No. of Visitors	40153	36244	45814	50419	48460	43977	36585
Foreign Exchange Earnings (T$ million)	15.9	15.8	12.3	14.4	14.06	14.14	-

There is a promotional emphasis on natural heritage sites, beautification of public areas, marine-based activities such as deep sea diving, snorkelling and whale watching and also wildlife conservation.

Figure 2: Number of tourist arrivals and foreign exchange earnings from tourism (1996-2002)



Source:

All this requires a clean green image which means support is being given to waste management such as removing unsightly waste dumps, restoring mangrove areas, and addressing pollution of the Lagoon. The TVB also strongly supports the introduction of the Water Resources Bill and advises that properly managed water is linked to the promotion of tourism. One of the first questions tourists ask “is the water safe?” The emphasis must be on promoting both the certainty of supply and improvement of quality (Powell 2006).

In addition to contributing to overall foreign exchange earnings, the tourism industry creates employment through demand for handicrafts, fishing and farming products, accommodation (hotels, motels, guesthouses*)* restaurants, travel agents, tour operators, private transportation services, professional/technical services and goods/products from retailers/wholesalers. This is all at risk if waterborne disease impacts on the tourist population or Tonga’s freshwater and coastal resources continue to be degraded by pollution.

On the other hand, tourism does create its own burdens on the environment through excessive use of water and detergents for laundry, bathroom, kitchens and cleaning of “luxury” accommodation and discharge of poorly treated wastewater to coastal areas.

The emphasis on eco-tourism will help to counter these impacts.

Promotion of cultural activities and products such as traditional dances, carvings and handcrafts, can indirectly deplete the natural resources so sustainable resource management plans are critical.

3.4 Watershed and coastal management

As previously discussed there is a direct link between watershed and coastal management, and there is a need to integrate technical and social factors to demonstrate the links and facilitate management. Research conducted on the coral atoll of Ha’apai and high karst island of Tongatapu has indicated that land based activities impact on lagoon and coastal waters, either through seepages of polluted groundwater or surface run-off. Collaboration between communities and government agencies is critical to addressing these issues.

3.4.1 Groundwater Pollution Study on Ha’apai -1998

The UNESCO study in Ha’apai 1996-1998 was conducted with personnel from the MLSNR, the TWB, the MOH and the teachers and students of St Joseph’s secondary school. The study focused on the question: “is there a safe distance for siting of sanitation facilities in relation to water supply sources?

The findings of the study were intended to contribute to guidelines on this complex issue, and are summarised below:

1. The water in the wells of the villages of Pangai-Hihifo were tested and in most cases the presence of faecal indicators was at an unacceptable level of concentration (E.coli >2000/100ml) for human and environmental health.
2. Samples taken from wells outside the village area had a much lower indicator count (E.coli<200/100ml). The groundwater in the village area was therefore assumed to be polluted from human and animal activity.
3. Groundwater samples taken from 4 points in proximity to a large septic tank system showed increasingly higher concentrations of E.coli at the points closest to the septic tank The sample from the closet point (2.5 m) to the septic tank overflow, had a distinct sewage odour. It therefore can be assumed that at least some of the pollution of the village groundwater was coming from the flush and pit toilets.
4. The questions then remained, 'how fast does the pollution move from the sanitation facility through the watertable, and is there a safe distance between pollution source and water supply source that will allow disease causing organisms (pathogens) to be rendered harmless by retention and dilution’.

5. The Bromide tracing experiment conducted in this study indicated that in the soil conditions and geology of the study area, diffusion through the watertable of disease causing micro-organisms could occur at a minimum rate of 5 metres a fortnight in all directions.

6. Some micro-organisms responsible for waterborne disease, such as viruses, can live for indefinite periods in cool wet conditions and other pathogens could survive the time taken from diffusion from a toilet to a well within 100 metres in any direction.

7. The Rhodamine-WT dye tracing experiment demonstrated a slightly faster rate of flow from the study area toward the coastal or west side of the island.

8. Survey of 50 wells in the village indicated that the groundwater levels were slightly lower on the west or coastal side of the village, offering an explanation why movement of tracers was slightly faster in that direction.

   Coral die-off was obvious in areas where septic tanks were located close to the reef.

9. The survey of water levels also indicated that the direction of flow was not always consistent and, at other points in the village it could be moving inland. Therefore, it cannot always be assumed that any protection will be provided by installing a pit or flush toilet on the coast side of a well. Change of direction could be due to the drawdown from the TWB pumps.

10. It is accepted that effluent from septic tanks and seepage from pit toilets can cause pollution of shallow aquifers. In 1977 the Environment Protection Agency in the USA designated areas with a septic tank density greater than 15 septic tanks per square kilometre as having potential contamination problems (Dillon 1996).

11. In the context of study site in the contiguous village of Pangai-Hihifo on Lifuka, there were approximately 3500 people living in an area of approximately one square kilometre. Most of the 300 house-sites in Pangai-Hihifo had one pit latrine, which was moved every 6-12 months around the house-site, and at least 50% also had a septic tank flush toilet within the house-site, This density of at least 300 toilets per square kilometre indicates widespread contamination of the aquifer.

12. Strategies to protect public and environmental health must address local beliefs and priorities to enable change in perceptions and behaviour.

13. From the social component of the study, it was established that private wells are an important and practical supply source for the people of Lifuka, and efforts should be made to protect the viability of the wells, even if an improved reticulated supply is provided. Enforced closure of private wells is not a constructive solution.

14. As the study indicates that there is no safe distance for siting of wells in relation to current toilet facilities in a village setting of the density of Pangai-Hihifo, strategies such as source control and water treatment are required to reduce the negative impacts of pollution on the aquifer and the coast.

15. Source control strategies being trialled in the village area included the use of composting toilets which do not discharge waste into the groundwater. The Health Inspector was also promoting the repair, covering and reinforcing of well structure to prevent ingress of pollutants through the wells.

16. Communication programmes need to be developed using visual and aural aids, which demonstrate the nature and movement of the aquifer and its susceptibility to pollution, and explores appropriate and practical strategies that can protect this essential resource. The programme could include the development of a model that used analytical equations describing commonly occurring hydrological conditions incorporated in a graphic display to illustrate the movement of nutrients and pathogens in groundwater. The video version would be adaptable to local languages and site conditions to provide an educational aid and management guide for minimum separation of waste sources from water supply wells, and from the coast" (Crennan 2001)

3.4.2 Environmental Management Plan for Fanga'uta Lagoon System 2000

Many studies and anecdotal observation on Fanga'uta Lagoon system on Tongatapu indicated eutrophication and the impact of pollution from land based activities. The Fanga'uta lagoon system includes important areas of seagrass and mangroves, critical for the environmental and economic health of Tongatapu. The following summary is extracted from the 'Environmental Management Plan for Fanga'uta Lagoon System' (Prescott et al 2000).

"In 1998 a project commenced to help protect the natural resources of Tongatapu for future generations to use. The Tonga Environment and Planning Project (TEMPP) worked with Department of Environment and Conservation (DEC) to look at the health of the Fanga'uta lagoon system. DEC, in collaboration with other ministries, NGOs and the community, reviewed these studies and developed strategies for protecting the lagoon's values, while allowing for its many important uses. These strategies were brought together in an Environmental Management Plan (EMP). The Draft EMP was circulated to communities, ministries and NGOs; and their views, ideas and concerns were recorded in a series of meetings around Tongatapu. It is with this information that the EMP was produced.

At Local Community meetings the following concerns were raised over the condition of the lagoon:

- Catching smaller and less fish.
- Rubbish and Litter.
- Loss of mangroves and erosion threatening people's properties.
- Loss of Seagrass.
- Sedimentation.
- Pollution.
- Loss of species and habitats.

The Environmental Management Plan was designed to improve the existing conditions in the lagoon and ensure that it can provide the maximum use of goods and services in the future. The EMP is a guide for action by Government, and action by individuals taking responsibility for their own environment. To provide guidance for development and spread the benefits of the lagoon as fairly as possible, a multi-use zoning plan was developed, based on scientific information and the voice of communities. This identifies eight different usage types within the lagoon's main ecosystem boundaries and the agencies and communities responsible for taking care of them.

Zone 1: Lagoon Entrance Fisheries Area

Zone 2: Lagoon Subsistence Fisheries Area

Zone 3: Conservation Areas

Zone 4: Sustainable Mangrove Use Area

Zone 5: Village and Agricultural Uses

Zone 6: Village Special Resource Use Areas

Zone 7: Urban Use Area

Zone 8: Special Public Use Areas.

3.4.3 Recommended strategies from communities

During the village-level consultations, numerous concerns were raised and strategies recommended by communities (Table 3.4.1). The following are key points:

- The Nobles, Town Officer and village communities and groups should be more involved and prominent in the process of developing and implementing the EMP;

- Village Fisheries Management Committees should be formed to prepare local management measures and to control outsiders fishing near the village fishing grounds;
- Minimum mesh sizes and maximum mesh lengths should be established and enforced by the Ministry of Fisheries;
- Present fishing bans should be enforced;
- Mangrove protection and replanting should be considered a priority and pigs should be fenced;
- All rubbish dumping to be banned, enforceable by fines;
- People should work together to decrease the importation of certain luxury products such as disposable nappies and plastic bags;
- There should be an increase in the use of local media channels to educate people of the benefits of improving their local marine environment.

Actions required and Agencies Responsible

Table 7: Major actions identified in the Plan

Action	*Responsibility/Agencies*
Implementation of EMP Zones	
Land allocation below present MHWM	Ministry of Lands, Survey and Natural Resources (MLSNR)
Commercial Fishing Aquaculture	Ministry of Fisheries (MAFF)
Subsistence fishing	MoF, communities
Mangrove removal	MoF, MLSNR, DEC
Seagrass removal	MoF, MLSNR, DEC
Mangrove use	MoF, MLSNR, DEC, communities
Mangrove rehabilitation	MLSNR, DEC, NGOs, communities
Reclamation	Ministry of Works (MOW), MLSNR
Seawalls	Ministry of Works
Dredging/sand and gravel extraction	Ministry of Works- Ports and Marine (P&M), MLSNR
Anchor and boat disturbance	Ports and Marines (P&M), Tonga Visitors Bureau (TVB), DEC, communities
Buildings	MLSNR, MOW, Ministry of Health (MOH)
Rubbish dumping	MOW, MOH, DEC, communities
Industry	Ministry of Labour Commerce and Industry, TVB, DEC
Tourism	TVB, DEC
Recreation	TVB, DEC, NGOs, communities
Research	DEC
Fishing	
Moratorium on fishing for one year.	MoF
Enforce fisheries closures (commercial fishing, mullet, fish traps and moratorium)	MoF

Set limits on fishing gear (50m length, 75mm mesh size)	MOF
Establish enforce and educate on minimum fish sizes	MOF, NGOs
Mangroves	
Education campaign on methods of sustainably using mangroves	DEC, NGOs, communities
Prevention of mangrove clearing	MLSNR, DEC, NGOs, communities
Seagrass	
Prevent clearing, anchor and boat damage	Establish working group between MOF, DEC, P&M and MLSNR
Stop seagrass decline caused by pollution, seawalls, dredging and runoff	Establish working group between MOW, DEC, P&M and MLSNR
Educate on the importance of seagrass for sustainable fisheries	MoF, DEC, NGOs, communities
Farm Practices	
Promote organic farming practice	Ministry of Agriculture and Forestry (MAFF), DEC, NGOs
Educate on the proper application of fertilizer and pesticides	MAF, Importers, NGOs
Encourage revegetation and vegetation retention on agricultural allotments.	MAF, NGOs
Urban Areas	
Improve the operations of sewage/ septic systems	Ministry of Health (MOH)
Encourage the proper disposal of garbage, oils and chemicals and prevent dumping within zone 5	MOH, DEC, Chamber of Commerce, oil companies
Cleanup of foreshore	NGOs, DEC, MOH Community Groups
Stop further sea wall development encroaching on lagoon	MLSNR, MOW
Stop further subdivision and development of residential land into the lagoon	MLSNR, MOW
Encourage fencing to stop pigs damaging the lagoon foreshore and mangroves.	NGOs, community groups, MOH, Prime Ministers Office
Create legal basis for 'Village Special Resource Use' areas.	MOF, DEC, MLSNR, communities

Source: (Prescott et al. 2000)

3.4.4 The International Waters Programme 2005

The International Waters Programme in Tonga focused on reducing the impact of community-based waste on freshwater water quality and the aquatic environment.

This summary of one of the research projects undertaken is extracted from 'Water Quality Survey, Nukuhetulu' by Palaki and Faka'osi:

"A pollution source survey was undertaken on the coastal waters adjacent to Nukuhetulu village in May 2005 to quantify the conditions of the Nukuhetulu aquatic environment. Samples were collected and analysed from five sites in the lagoon and two sites from underground water using 27 variables; 10 chemical, 7 physical, and 10 biological indicators.

Physical parameters varied between two sites with temperature being slightly higher, as water became more turbid. Faecal coliform counts exceeded the Australian Standard for Food in most of the sites. Nutrients levels in all sites were below the detection limit except nitrate which was high and limiting. Seagrass with epiphytes were between 80-100%.

The quality of water around Nukuhetulu village is a concern and the following is recommended: communicate the survey results to the people of Nukuhetulu and the wider public, set up demonstration of cost effective community-based solutions that can reduce the impacts of both point source (e.g. sewage) and non-point source pollution (e.g. animal waste and agricultural chemicals), and develop an integrated waste management strategy to address the root causes of water degradation pollution. The strategy should outline medium and long term targets on what and how to reduce inputs from different sources of pollution from land. Ultimately, it is envisaged that reduced waste impact improves water quality and health of the people of Tonga" (IWP Tonga 2005)

As previously discussed, there is an ongoing need for coordination of relevant agencies in regard to management of water resources and wastewater, including its relationship to sustainable coastal management. This would be facilitated by the practical implementation of the Water Resources Bill.

4. STAKEHOLDER ENGAGEMENT

Information was gathered initially from reports, and updates for current conditions was collected from email and telephone correspondence and a week's field trip to Tongatapu in February 2007 which included discussions with personnel from relevant ministries, non-government organisations, and community members, and personal observations. Access to institutions and information was limited because of the shortage of staff that has occurred since the public service was reduced by 1000 people in mid 2006. In some cases data and information that these people were responsible for is misplaced or difficult to find. The government personnel who have taken their place now have additional responsibilities, and are currently in the process of adjusting to new and multiple roles, and in some cases within recently amalgamated or relocated divisions. In addition many of them are already on a range of committees initiated by donor funded programmes. In some agencies there was reluctance to share information.

At each interview conducted in Tonga during the February visit, the IWRM project was explained, and the relevance and opportunity for personnel to participate in ongoing activities was discussed. This included being a member of the National Water Resources Committee, contributing to the Hot Spot Analysis, and development of the Demonstration Project.

Table 8: Stakeholders and Institutions Consulted

Institution	Stakeholders interests/responsibilities	Relevance to IWRM/reason for inclusion	Role in contribution process
MINISTRY OF LANDS SURVEY NATURAL RESOURCES and ENVIRONMENT	-responsible for management and monitoring of water, coastal and mineral resources, and seismic activity - management of the state of the environment; -national coordination of actives and programmes related to MEAs including implementation, monitoring and evaluations -issuing permits and conducting environmental impact assessments	Focal Point for GEF/IWRM project Hydrogeology/hydrology unit within Natural resources section of MLSNRE New Planning and Urban Management Division established within MLSNRE Climate Change Section established within Environment dept. Member of the Water	Consultation with Focal Point on approach to diagnostic report, Hot spot analysis and concept paper practical implementation of Water Resources Bill, and priorities and obstacles re water resource management Consultation with outgoing IWP Coordinator on work conducted to address impact of waste/waste water on water

Institution	Stakeholders interests/responsibilities	Relevance to IWRM/reason for inclusion	Role in contribution process
	- Managing or participating in any project, or part of a project, aimed at implementing any aspect of environmental concerns - Disseminating information to local stakeholders and creating public awareness on environmental concerns -Responsible for land management and all matter relating to land, natural resources and environment -Responsible for monitoring of environmental issues in Tonga - Biodiversity stocktake	Safety Plan (WSP) Committee Member of National Emergency Management Committee Member of National Committee on Climate Change (NCCC)	resources. Consultation with Head of Environment and Nat. Resources on needs for capacity-building, training and research and co-ordination of relevant programmes. Arrangements for stakeholder consultations on IWRM priorities. Hot Spot Analysis and establishment of National Water Committee Geodesy dept for seas level rise data, Biodiversity data
MINISTRY OF HEALTH	Responsible for rural water supply and sanitation Responsible for monitoring water quality of reticulated systems Responsible for surveillance and early warning for vector-borne and water-borne diseases	Member of the National Committees on Climate Change, and Emergency Management, and the WSP committee Approves and inspects rural water supply systems, and sanitation systems throughout Tonga. (urban and rural)	Consultations on information and data on the health impacts of poor management of water resources and sanitation Limited capacity for monitoring water quality of village water supply Provision of health statistics relating to water borne diseases Membership of IWRM Nat Water Resources Committee
METEOROLOGICAL SERVICES	The Tonga Meteorological Service (TMS) is responsible for operation and maintenance of the climatic stations in all the island groups, and collects data on rainfall, droughts, temperature, and cyclones	Member of National Emergency Management Committee Member of the NCCC	Consultations on data and information on rainfall, droughts, cyclones, temperatures, for Tonga. Membership of IWRM Nat Water Resources Committee
TONGA WATER BOARD	Responsible for the planning, installation, operation and maintenance of public water supply systems in selected urban area of Tongatapu, Eua, Va'vau, and Ha'apai	Member of the Disaster Management Committee Member of WSP committee Member of the NCCC Contractual work upgrading village water supply systems	Consultations on information and data on technology and financing issues Membership of Nat Water R Committee
TONGA TRUST	Facilitates social, human, community and environmental development and training - eco-forestry, pesticide awareness, environmental education, community theatre, and sanitation	Provides training and support to rural communities on rainwater harvesting programmes. Member of the Disaster Management Committee	Membership of IWRM National Water Committee. Ongoing work from IWP Consultations on the possible role for Tonga Trust in village water

Institution	Stakeholders interests/responsibilities	Relevance to IWRM/reason for inclusion	Role in contribution process
	Women's' development and health issues, including water supply , and poverty alleviation		supply training
MINISTRY OF WORKS	Responsible for capital works The Ministry of Works owns and operates the only drilling rig used for installation of bore holes Hosting Solid Waste Management Project National Disaster Management Office.	Bore drilling procedures Solid Waste Management Project Waste Management Authority Treating and monitoring leachate at new waste management facility National co-ordinator for emergency management	Membership of IWRM National Water Resources Committee. Restoration of previous dumpsite Water emergency plans
MINISTRY OF AGRICULTURE, FORESTRY and FISHERIES	Promoting agricultural and forestry production and supervising fisheries	Supervising use of fertilisers, pesticides and irrigation Member of the Disaster Management Committee	Consult re lack of facilities for monitoring contamination of groundwater by pesticides and fertilisers, or records of who is using groundwater irrigation systems. Potential demo projects on rainwater harvesting for irrigation/model farms Membership of IWRM National Water Committee
CENTRAL PLANNING DEPARTMENT	Responsible for the overall coordination and monitoring of aid projects, and for coordination of development plans including those affecting the water sector	Member of the Disaster Management Committee	Consult re rural water supply and rainwater harvesting projects Membership of IWRM National Water Resources Committee
NGOs -Mainstreaming of Rural Development Initiative -Langafonua	Facilitates social, human, community and environmental development and training especially in rural and remote areas. Women and family economic initiatives	Focus on rural and remote areas. Rainwater harvesting programmes	Potential involvement in IWRM demo project Community needs re water and wastewater management
DONOR AGENCIES AusAID NZAID JICA ADB	Responsible for administering funding bi-lateral projects including water, sanitation and urban planning programmes		Advise re IWRM project and discuss collaboration and inter-linkages.

All the government and NGO stakeholders suggested that there should be a focus on various aspects of village water supply relevant to their field. Consequently a trial hot spot analysis was conducted in consultation with the IWRM Focal Point covering a number of different approaches to a village based demonstration project. The example of Basseterre Valley from the Caribbean was used as a guide for comparison. The ideas suggested by the IWRM Focal Point scored highly. These

and other possibilities will be followed up when the National Water Resources Committee will conduct a group Hot Spot Analysis at their first meeting at the end of March.

5. OTHER PROGRAMMES, PROJECTS AND ACTIVITIES RELATED TO IWRM

5.1 Bi-lateral and other programmes

- The Mainstreaming of Rural Development Initiative hosted by the Civil Society Forum, Tongan National Youth and the Catholic Women's League. Interested in assisting with community participation in the water and sanitation sector. T$1 million per year for four years. Contact: Soane Patolo – Project Coordinator
- AusAID. Small grants for rainwater harvesting systems AU$500,000 nationally. Drainage of house sites in Nuku'alofa swamps (Sopu) AU$200,000. Contact: Tofavaka Tamoua, Program Manager. Development Cooperation or Gabriel Manager, Activities Manager, Australian High Commission, Tonga
- NZAID 'Eua Village Water Supply T$5.5 million, three Rural Village Water Supply Systems $T3million. Contact: Pelenatita Kara. Development Programme Coordinator: Pelenatita.Kara@mfat.nz.
- JICA. Upgrade Village Water Supply Systems-average 8 per year. Approx US$ 450,000 annually. Contact Oka Tu'umoto'oa.Hiroko: Oka.Hiroko@jica.go.jp
- Asian Development Bank Tonga Integrated Urban Development (Project Contact: Richard Mabbitt mabbittrg@aol.com. Ministry of Works. Loan to be negotiated.

  Components and subprojects of Integrated Urban Development Project

Drainage	
Drainage Rehabilitation and Maintenance Program	Improvement of the existing drainage system in the town's central commercial area, and along the main sea frontage of Vuna Road. It will include the purchase of street sweeping equipment to reduce build up of debris. It will also include purchase of a jet/vacuum truck for the cleaning of the existing storm sewers.
Sopu Drainage Channel	A gabion-lined drainage channel through the low-lying, swampy area of Sopu, connecting the largest isolated open water areas the watershed outlet. The channel will serve as a means for these areas to periodically "flush" during storm events, thereby reducing the existing health hazards. The channel will provide a drainage route during storms to prevent back-up and runoff into existing homes.
Residential Infiltration Promotion Program	Assistance to residents to reduce flooding and ponding in their yards following a rainstorm. It will include development of a manual, a public awareness program, and a low-interest community finance facility from which residents can borrow to construct their infiltration devices.
Roads	
Taufa'ahau Road Upgrade	The resurfacing and widening of the vehicular road surface on the town's main arterial route. It will provide a turning lane and construction of sidewalks on both sides of the road, and rehabilitation of the existing stormwater collection systems.
Alaivahamama'o Road Upgrade	Resurfacing, widening and provision of side walks on of one of Nuku'alofa's busiest roads, used by commuter and industrial traffic as well as pedestrians. Rehabilitation of the existing stormwater collection systems.
Primary Roads Upgrading	A lump sum allocation for improvement of priority primary roads. Selection of specific roads to be made during project implementation.
Secondary and Access Roads Surfacing	A lump sum allocation for surfacing and extension of minor roads in the urban area. Selection of specific roads to be made during project implementation, but expected to include roads in Popua and Sopu.

Sanitation and Sewerage	
Monitoring Wells	The installation of eight monitoring wells in strategic locations in the urban area to facilitate collection of data on groundwater quality, particularly in relation to the impact of septic systems on the well-field and the lagoon.
Residential Septic Tank Improvements Program	Assistance to residents in replacing septic tanks that are either undersized or improperly constructed. It includes a public awareness programme, and a low-interest community finance facility from which residents can borrow to construct or improve their septic facilities.

- GPA Global Programme of Action for the Protection of Marine Environment form Land Based Activities has supported training in Improvement of Municipal Wastewater Management in Coastal Cities. This training is ongoing but needs to be further tailored to the conditions which exist in the urban areas of Pacific SIDS.

5.2. Regional sector support projects

Water Demand Management (WDM)

Water Safety Planning (WSP)

Water Quality Monitoring (WQM

Hydrological Cycle Observing System (HYCOS)

Island Climate Update (ICU)

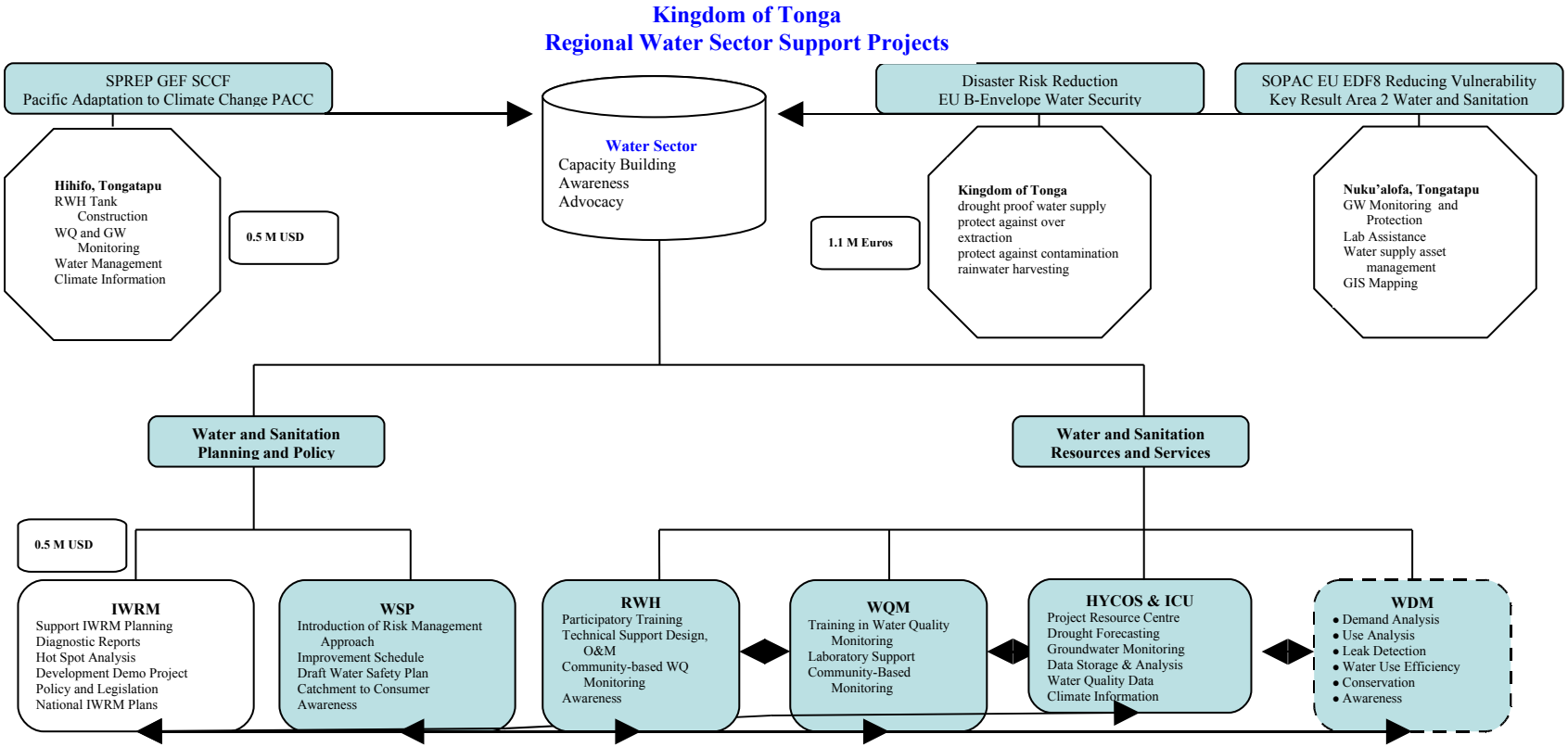
Rainwater Harvesting (RWH)

Pacific Adaptation to Climate Change (PACC)

Reducing Island Vulnerability (EDF / B-Envelope)

Please see Figure 3 for overview of projects, goals and inter-linkages. (Source: Marc Overmars, SOPAC).

Figure 3: Regional Water Sector Support Projects



Project Acronyms	Partner Organisations	Donor Agencies	Tonga Government Counterparts	Timeframe
WDM = Water Demand Management	SOPAC & PWA	NZAID	TWB	2006-2009
WSP = Water Safety Planning	SOPAC & WHO	AusAID	TWB, MOH, MOE	2006-2007
WQM = Water Quality Monitoring	Institute Pasteur	France	TWB	2006
IWRM = Integrated Water Resources Management	SOPAC & UNDP & UNEP	GEF IW / EU Water Facility	TWB, L&S, MOH, DOE, TMS	2006-2007 and 2008-2012
HYCOS = Hydrological Cycle Observing System	SOPAC & WMO & UNESCO	EU Water Facility	L&S, TWB, DOE, TMS	2007-2010
ICU = Island Climate Update	SOPAC & SPREP & NIWA	NZAID	TMS, L&S, TWB	2004-2008
RWH = Rainwater Harvesting	SOPAC & TCDT & UNEP	SIDA	TWB, MOH, L&S, TCDT	2002-2005 contd.
PACC = Pacific Adaptation to Climate Change	SPREP	GEF SCCF	TWB, L&S, MOH, DOE	2006-2007 and 2008-2012
EDF / B-Envelope = Reducing Island Vulnerability	SOPAC	EU	TWB, L&S, MOH, DOE, TMS	2003-2007 and 2008-2010

6. CAPACITY DEVELOPMENT NEEDS FOR REMOVING BARRIERS

6.1 Human Resources

The Natural Resources Division is understaffed. Five people share responsibility for activities relating to geology, seismology, oceanography, coastal and minerals management including aggregate and sand extraction, and water resources management and monitoring including approving permits for bores. The senior hydrogeologist accepted redundancy mid 2006. At least one dedicated staff is required to focus on water resources management. As government policy is currently to reduce the public sector, it may be necessary to contract retired skilled staff to assist with specific tasks.

The Ministry of Health is only capable of conducting two biological sampling sessions a year at each village water supply system. This is partly to do with available staff, but also because testing has to take place in the same laboratory that human specimens are tested. Environmental Health officers have many other duties besides testing water supply and monitoring toilets. Dedicated facilities and additional staff are required for biological water quality analysis.

6.2 Training

Collection of water samples and testing for biological and chemical quality (including agrichemicals) needs to be centralised, with necessary facilities, equipment, and reagents secured.

Village water committees require training in maintenance and monitoring of water supply systems. Other village members should be encouraged to join in training sessions where possible.

Householders need training in the design, construction and maintenance of rainwater harvesting systems, sanitations systems and private wells.

Water managers have expressed a preference for specially designed in-country courses, and on-the-job training. It has been observed that regional training often does not address the specific needs which exist in Tonga, in terms of level of expertise, available equipment, local hydrology/hydrogeology and geographic and socio-cultural conditions.

Farmers need training in the safe use of pesticides and fertilisers, and organic farming techniques based on traditional local gardening practices, including niche marketing.

A National Water Resources Committee will require support for establishment and ongoing communication, keeping in mind that the public service is generally understaffed and membership and attendance on committees is time consuming. The committee and its associated members require training in integrated planning, policy and legislation review, community engagement skills, and promotion of public awareness.

There is a need for capacity building in drought planning, water demand management, cost recovery, improved fuel and pesticide management, and ecological surveying for all relevant agencies and operators.

7. INTRODUCING AN INTEGRATED APPROACH TOWARD BARRIER REMOVAL

The suggestions in this section all require some kind of financial support to achieve, but the emphasis should be to build on existing skills and relationships, to facilitate cooperation and sharing of resources and information, and to nurture traditional and cultural values and knowledge of resource management.

Comprehensive water resources legislation in the form of the Water Resources Bill which is before Cabinet should be enacted in the near future. All steps should be taken to facilitate this

process. The new Water Resources Act should then be implemented, providing for effective planning, assessment, development, control, monitoring and protection of water resources throughout the Kingdom of Tonga.

The Water Resources Act will provide a mandate for the Ministry of Lands, Survey Natural Resources and Environment to control and monitor the water resources of Tonga. It will administer the provisions of the Act and coordinate other agencies in supporting roles, providing an opportunity for integrated planning and ongoing adaptive development of a national water policy and strategy.

While regulations and guidelines will be necessary, a partnership approach should be developed with the community to ensure compliance. This includes all water users, and also landholders who are providing access to groundwater. A National Water Resources Committee will be established to keep all stakeholders involved and informed, and to assess training and capacity building requirements.

The water resources monitoring programme conducted by the Hydrogeology/hydrology Unit of the Ministry of Lands, Survey, Natural Resources and Environment should be practically strengthened to become an effective national monitoring program with supplementary information provided by the Tonga Water Board, Ministry of Health Village Water Committees, and NGOs and CBOs involved with rainwater harvesting programmes.

Salinity measurements of the groundwater should be used as the primary means of groundwater monitoring and resource evaluation with other methods including measurements of watertable movement as useful secondary approaches.

Permanent monitoring systems to obtain vertical salinity profiles should be installed in the freshwater lenses on Tongatapu, Lifuka in the Ha'apai Group and Vava'u so that they can be monitored at regular intervals. Installation costs associated with drilling should be funded, where necessary, by an external funding agency.

All existing bores, both government and private, should be assessed and location, purpose and estimated usage recorded. Pump sizes and extraction rates should be controlled.

The groundwater resources database at the Hydrogeology Unit should be maintained to include all current water resources information including surface water flows, rainfall and climatic data, and biological and chemical water quality, and analysis and modelling systems should be regularly updated. The data base should be available to other agencies, and relevant stakeholders.

An additional staff member should be allocated to the Hydrogeology Unit to assist with the collection processing, archiving and analysis of hydrological and hydrogeological data, and on-the-job training should be provided to relevant staff.

Householders should be provided training in the design construction and maintenance of a range of on-site sanitation systems, particularly septic tanks and composting toilets. Training should include the advantages and disadvantages of the various systems including graphically demonstrated environmental and health impacts of the treatment/disposal process.

Householders should be trained in the design construction and maintenance of rainwater harvesting systems. NGOs which have assisted with revolving loans and other fundraising activities should be engaged to offer further support.

Householders should be trained in the design construction and maintenance of private wells, in communities where these are still used, and traditional pride in the family well recognised and encouraged.

Where possible training should equip the trainees to a standard where they could be contracted to assist other householders to construct and maintain their water supply and sanitation systems.

Farmers should be trained in organic farming techniques based on traditional local farming practices and introduced to niche organic markets in developed countries. A model farm could

be established to demonstrate irrigation by rainwater harvesting, use of organic pest control and fertilisers (including pig manure and compost), ecological sanitation including management of livestock, especially pigs, and sustainable rain water and groundwater management.

Tourism in Tonga should be further marketed as a ‘clean green experience’ to encourage and support an integrated approach to the management of water and all other natural resources within the country.

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ANNEXES

ANNEX 1: Monthly Rainfall

Source: Tonga Meteorological Services
DATA REQUEST- Ministry of Lands Survey Natural Resources and Environment

Monthly Rainfall (mm)

Nuku'alofa												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	227	85	51	285	145	158	213	49	75	8	197	145
1995	69	212	184	73	48	139	101	25	38	23	81	22
1996	469	87	411	70	166	163	29	80	69	233	68	210
1997	256	405	218	161	68	18	50	126	74	103	37	65
1998	16	90	483	34	72	76	41	32	103	53	207	421
1999	153	410	152	300	80	148	134	205	148	345	276	189
2000	336	314	348	324	154	92	236	97	97	99	67	244
2001	508	229	163	170	25	127	69	98	103	20	68	123
2002	84	572	197	218	81	63	231	154	143	37	95	49
2003	319	17	207	92	49	44	109	265	87	40	27	129
2004	103	124	252	41	69	146	118	336	288	26	41	53
2005	146	15	172	293	195	150	143	102	118	244	179	38
2006	325	260	199	215	39	170	54	73	119	75	72	98
Fua'amotu												
1994	248	185	44	283	99	168	173	57	141	31	180	174
1995	133	137	190	86	38	164	129	21	56	31	133	29
1996	533	42	216	112	169	215	39	95	77	108	54	212

1997	263	356	164	163	720	17	72	157	90	116	21	112
1998	13	45	329	36	53	76	62	28	96	54	367	391
1999	201	487	103	331	30	146	159	245	153	301	219	217
2000	434	370	413	304	132	68	227	88	78	171	65	229
2001	466	150	222	159	41	155	77	149	92	33	167	157
2002	132	489	285	327	84	47	235	121	199	27	102	68
2003	413	30	321	78	38	16	116	221	76	62	42	135
2004	84	98	253	36	127	211	164	355	262	33	38	108
2005	259	15	144	313	158	172	165	133	125	317	179	49
2006	194	153	137	357	34	359	70	90	101	99	43	293
Ha'apai												
1994	97	155	71	100	43	98	130	20	68	114	260	123
1995	10	94	259	136	48	116	67	75	33	11	120	24
1996	464	56	268	82	134	60	13	47	23	126	76	219
1997	213	315	133	287	98	13	108	94	93	73	70	89
1998	42	68	124	66	28	108	75	21	2	11	179	369
1999	161	332	149	200	18	138	55	138	233	339	284	162
2000	268	194	447	497	202	27	197	75	89	97	106	125
2001	225	153	184	66	137	216	186	54	34	40	67	403
2002	71	205	327	112	88	31	113	177	100	32	163	130
2003	329	43	122	113	83	32	50	103	63	68	80	109
2004	70	187	294	163	114	197	125	225	213	5	185	41
2005	65	107	103	305	166	173	163	124	156	244	117	39
2006	415	319	67	181	29	162	99	19	144	73	123	49
Vava'u												

1994	277	183	111	127	362	132	108	6	73	143	52	386
1995	82	138	335	219	193	89	76	134	61	181	132	61
1996	686	134	343	49	207	203	59	95	68	148	79	461
1997	185	348	299	243	211	35	152	127	165	183	62	153
1998	148	100	212	52	30	100	60	32	14	7	157	271
1999	91	356	178	179	113	203	85	56	300	283	287	264
2000	609	234	431	454	291	58	156	62	385	254	135	217
2001	216	294	398	289	138	380	144	88	20	56	78	243
2002	117	298	221	396	212	39	131	137	296	103	164	99
2003	263	143	396	132	45	12	188	145	96	111	62	591
2004	173	180	337	320	316	440	69	170	147	173	198	217
2005	235	125	198	1009	149	181	171	158	298	172	275	166
2006	322	313	108	339	394	195	112	37	191	147	67	71
Niuatoputapu												
1994	289	142	199	305	155	194	151	102	91	112	226	408
1995	45	166	364	399	110	127	105	333	117	119	205	160
1996	608	190	343	138	207	233	61	48	100	167	49	213
1997	184	270	350	104	206	350	180	100	122	110	90	129
1998	70	112	303	71	21	66	50	29	23	12	161	333
1999	326	422	94	141	235	212	237	265	441	178	317	195
2000	436	130	385	204	160	45	115	103	120	396	80	260
2001	170	260	232	262	247	478	66	105	7	303	133	323
2002	224	232	328	181	246	45	113	198	54	79	254	208
2003	212	44	168	295	152	86	92	53	53	203	233	262
2004	224	122	274	196	102	220	54	52	48	174	136	125

2005	106	21	173	332	2	86	7	60	147	133	141	
Niuafo'ou												
1994	362	68	441	207	120	92	98	46	98	195	374	556
1995	400	202	456	346	129	103	143	442	203	137	227	99
1996	472	380	458	142	208	296	56	63	136	177	243	238
1997	231	375	412	99	204	305	194	232	131	110	89	126
1998				91	57	71	26	61	81	19	175	324
1999	659	411	208	277	125	56	168					281
2000	210	231	338	155	160	173	138	78	218	183	238	224
2001	209	228	216	90	196	392	62	101	32	137	157	417
2002	125	365	213	463	206	49	154	212	151	118	70	218
2003	377	143	225	209	349	47	111	44	62	100	208	412
2004	84	276	523	178	291	437	52	62	155	173	240	479
2005	378	183	343	635	45	378	94	150	156	157	480	511
2006	672	846	159	198		154	131	126	44	477	213	474

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List of Tropical Cyclones that have affected at least a part of Tonga from 1960 to date

Name	Date	Min P	Area	Extreme Wind	Centre
Nil	17 -19 Jan 1960		NTT/VV	Est. 60kt gust 90kt(Storm)	N/A
Nil	14 -19 Mar 1961		VV/HP/TBU	100kt gust 150kt (Severe)	N/A
Nil	22-23 Nov 1964		S/Tonga	40kt gust 55kt (Minor)	N/A
Nil	25/26 Feb 1969		S/Tonga	N/A	N/A
1969-1970 (El-Nino)					
Nil	11-12Jan70	990(NZ)	Tonga	Gale	
Dolly	11-25Feb70	965(NZ)	Tonga,Niue, Samoa	Gale	
Gillian	8-11 Apr1970	980(NZ)	Tonga	Hurricane	
Helen	13-16Apr	990(NZ)	Tonga, Wallis & Futuna	Storm	
1970-1971					
Nil					
1971-1972					
Nil	18-24 Jan	990	Tonga, Niue	Storm	
1972-1973					
Bebe	19-28 Oct	945	S/Tonga,Fiji,Tuvalu	Hurricane	
Collete	2-3 Nov	990	N/Tonga,W & Futuna	Storm	
Elenore	31Jan-7Feb	980	N/Tonga,Niue,Smoa,S/Cooks	Hurricane	
Juliette	3-4 April	980	S/Tonga(Ha'apai), Fiji	50kt gust 75kt(Hurricane)	N/A
1973/1974					

Annex 2 Cyclone Records

Lottie	5-12Dec	960(NZ), 963(NC)	S/Tonga,,New C,Fiji	Hurricane	
1974-1975					
Val	29Jan-5Feb	945	Tonga,Samoa,Fiji,W&Futuna	Hurricane	
1975-1976					
Nil					
1976-1977					
UN-Named	3-9Feb	990	S/Tonga, Fiji	Storm	
Pat	15-18Mar	980	Tonga, NIue	Hurricane	
1977-1978 (El-Nino)					
Anne	25-31Dec	980	Tonga, Niue, Fiji Futuna	Hurricane	
Ernie	16-23Feb	980	Tonga, Fiji	Huricne	
1978-1979					
Leslie	21-23Feb	980	Southern Tonga	Hurricane	
Meli	24-23Mar	920(FJ)	Northern Tonga	Hurricane	
1979-1780					
'Ofa	10-15Dec	980	Northern Tonga	Hurricane	
1980-1981					
Betsy	30Jan-3Feb 1981	990	Tonga, Niue	40kt gust 52kt(Storm)	N/A
Cliff	8-15Feb	970	Tonga,Niue,Vanuatu,N/Caledonia	Hurricane	
Un-named	16-20Feb	990	Tonga, Fiji,Niue,S/Cooks	Storm	
Daman	20-24Feb	980	Northern Tonga	Hurricane	

Name	**Date**	**Min P**	**Area**	**Extreme Wind**	**Centre**
1981-1982					
Issac	27Feb-5Mar	930	Hp/ TBU	90kt gust 130kt(Hurricane)	Eye passed over Hp

1982-1983 (El-Nino)
NIL
1983-1984

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Lance	3-8Apr	985	Tonga, Wallis	Hurricane	
Un-named	22-30 Mar		Tonga	40kt gust 53kt	N/A
1984-1985					
Drena	11-14 Jan	987	Niuatoputapu	Est. 50kt gust 70kt(Storm)	20 miles West of NTT
Eric	14-20Jan	955			
1985-1986					
Keli	8–12Feb	987	Tonga, Fiji,Vanuatu	50kt gust 70kt(Storm)	N/A
Lusi	2-10Mar	990	Tonga, Vanuatu,N/C	Storm	
Martin	10-14 Apr	970	Ha'apai, Fiji	40kt gust 60kt (Hurricane),	Eye passed over Kia Is.
1987-1988 (El-Nino)					
1988-1989					
Un-named	7-14 Feb	987	Tonga,Fiji	35kt gust 50kt (Storm),	N/A
Kerry	29 Mar-3Apr	985	Tonga, Fiji	50kt gust 65kt(Hurricane)	N/A
1989-1990					
'Ofa	30Jan- 10Feb	987	Tonga(Ntt), Niue, Samoa	Est. gust 140kts(Hurricane)	30 miles West of Niue
1990-1991					
Sina	24-Nov -4Dec	960	Tonga(TBU/ HP),Niue, Fiji,	65kt gust 100kt(Hurricane)	N/A
1991-1992 (El-Nino)					
Val	4-13 Dec	940	Tonga(NTT),Samoa, Tokelau	Est. 50kt(Hurricane)	Close to Savai'I
1992-1993					
Joni	6-13 Dec	940	Tongatapu,Fiji,Tuvalu	Hurricane	Lau group
Nina	23Dec-5Jan	955	Nfo/Ntt/Vv,Fiji(Rotuma)	Hurricane	N/A
Kina	26Dec-5Jan	955	Tongatapu,Fiji	gust 120kt(Hurricane)	Southern Lau
Mick	5-9 Feb	987	Vv/Hp, Fiji	Storm	N/A
1993-1994 (El-Nino)					
1994-1995 (El-Nino)					
1996-1997					
Hina	12 -21Mar	970	TBU/'Eua	50kt gust 90kt(Hurricane),	West of Fua'amotu

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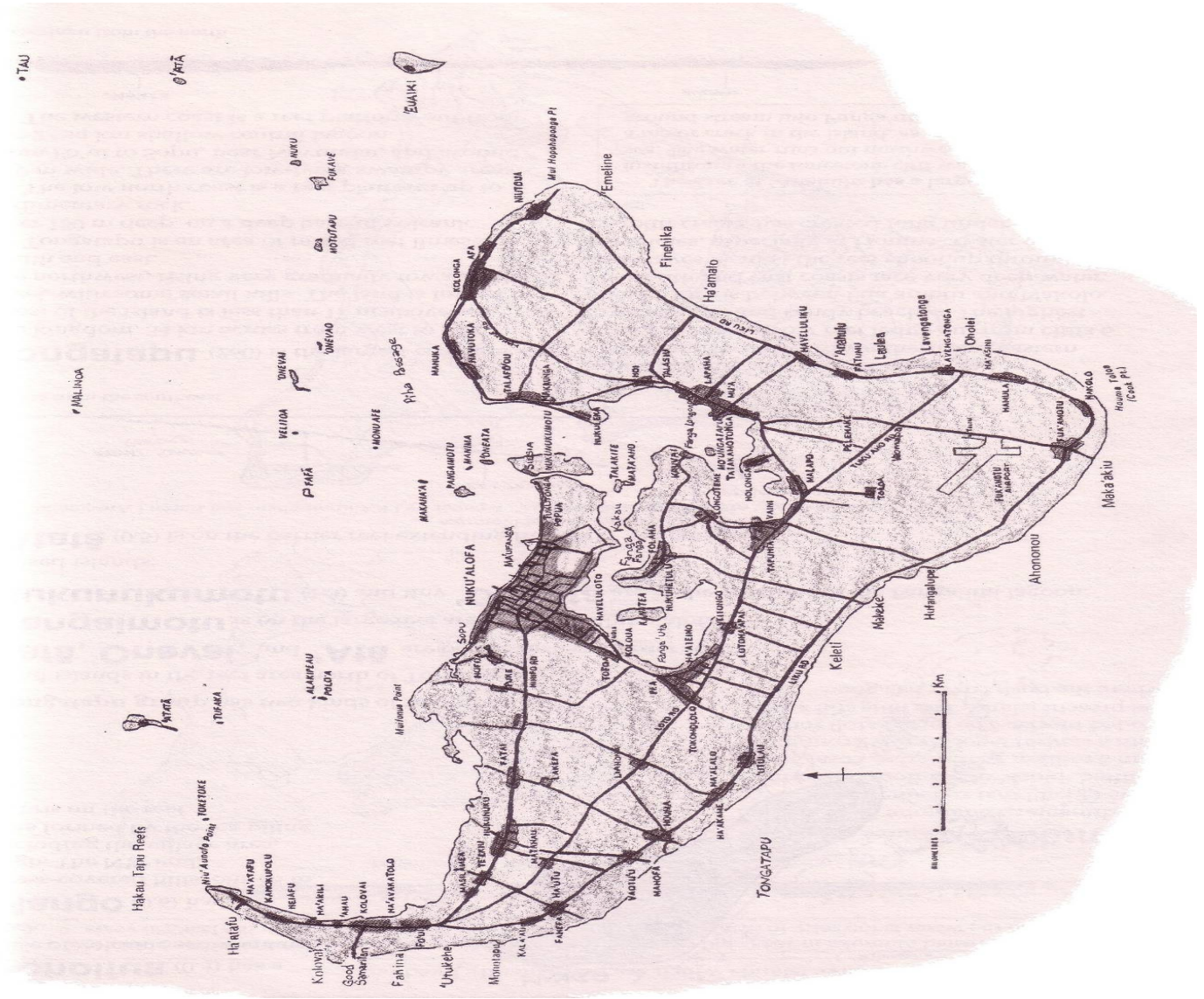
Keli	10-15 Jun	955	Nfo, Ntt ,Fiji, Tuvalu	Est. gust 100kt(Hurricane)	300km East of Lakeba, FJ	
1997-1998 (El-Nino)						
Ron	1-8 Jan	900	Niuafo'ou,Samoa,Wallis	Est. gust 125kt(Hurricane),	eyes passed NFO	
1998-1999						
Cora	23-30Dec	960	Tt/Hp/'Eua, Fiji,Wallis	47kt gust 73kt(Hurricane)	19 miles East of TBU	
1999-2000						
Mona	8-10Mar2000	960	Tt/Hp/'Eua	44kt gust 65kt(Hurricane)	30 miles West of TBU	
2000-2001						
Paula	26Feb-8 Mar	930	Tt/Hp/'Eua, Fiji, Vanuatu,	40kt gust 60kt(Hurricane)	200 miles SW of TBU	2001-**2001-2002**
Waka	29Dec01-1Jan02	930	Nfo/ Ntt/ Vv,	100kt gust 140kt(Hurricane)	eye passed over VV	
2002-2003 (El-Nino)						
Yolande	5Dec2002		Tonga waters, no land areas	gale		
Ami	110-15 Jan2003	950(FJ),994(TBU)	TT/EUA, Fiji	40kt gust 60kt(Hurricane)	120 miles SW of TT	
Cilla	27-28 Jan2003	993(Hp)	Tonga(Ha'apai)	28kt gust 58kt(Gale)	eye passed over Lifuka	
Eseta	13-14 March03	994(TBU)	TT/Hp	40kt gust 60kt(Gale)	eye passed 60 miles	
Fili	16April2003		Tonga Waters,	Gale		
2003-2004						
Heta	5-6 Jan2004		Nfo/Ntt,Niue, Samoa	Est 80kt gust 100kt	eye passed east of NTT	
2004-2005						
Lola	30Jan05-1Feb05	997(Tbu)	Tbu & 'Eua	26kts gust 47kts		
2005-2006						
Tam	12-13 Jan2006	991(Nfo)	Niuafo'ou	40-45kts gust 50kts		
Urmil	14-15 Jan2006	994(Ntt)	Niuatoputapu	40-45kts gust 60kts		
Vaianu	11-15 Feb2006		All of Tonga	35kts gust 54kts		

ANNEX 3: Land Use - Tongatapu
Source: Ministry of Lands Survey Natural Resources and Environment



ANNEX 4: Land Use – Nuku'alofa, Tongatapu

Source: Tonga integrated Urban Development Project. MOW/MOF